

on the upper border of the larger chela, there being here no transverse groove, by the stouter shape of the smaller chela, by the dactyli of the 3rd and following legs being armed with two accessory claws, etc.

EXPLANATION OF PLATE LXX.

Alpheus ehlersii.

Fig. 1. Frontal and antennal region of the larger specimen, $\times 23$.

Fig. 2. Telson of the same, $\times 23$.

Fig. 3. Larger chela and carpus of the larger specimen looked at from the inner side, $\times 8\frac{1}{2}$.

Fig. 4. Smaller chelipede of the same, $\times 8\frac{1}{2}$.

Fig. 5. Second leg of the younger specimen, $\times 11$.

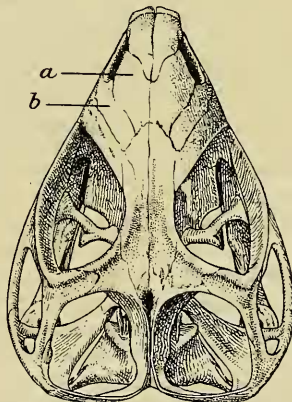
Fig. 6. Fifth leg of the larger specimen, $\times 23$.

June 15, 1909.

DR. A. SMITH WOODWARD, F.R.S., Vice-President,
in the Chair.

MR. H. W. UNTHANK, F.Z.S., exhibited a skull of *Sphenodon* with two bones on each side in the nasal region, and made the

Text-fig. 214.



Sphenodon skull with abnormal nasal region.

a. Left median bone in nasal region.

b. Left external bone in nasal region.

following remarks:—"In place of the usual single nasal on each side there appear to be two bones, one near the median line, the other more external, the line of division running from before

backwards (text-fig. 214). On sawing across the middle of the nasal region the anterior part of the median pair of bones came away with the premaxillæ and vomers, leaving the external bones *in situ*. These show bevelled inner edges where they were slightly overlapped by the median bones, so that the surface-marking is that of a suture in the middle of what is usually a single nasal bone."

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The Ears of an Elephant from British East Africa.

The Secretary exhibited the ears of an Elephant shot by Mr. Sutton Timmis, F.Z.S., on the Guaso Ngishu Plateau, east of Mt. Elgon, British East Africa. The ears of this elephant (text-fig. 215) were elongated vertically, with an arched upper

Text-fig. 215.



Right ear of an Elephant (*Elephas africanus peeli*) from the Guaso Ngishu Plateau, British East Africa, from a specimen shot by, and in the possession of, Mr. Sutton Timmis, F.Z.S.

border, and a long, relatively narrow, and pointed lappet. The general shape corresponded closely with that of the ears of the elephant from the Aberdare Mountains, British East Africa, figured by R. Lydekker (P. Z. S. 1907, p. 393, text-fig. 114). The vertical length (4 feet 9 inches) and the greatest breadth

(3 feet 2 inches) were greater than the corresponding dimensions of Mr. Peel's specimen, described by Mr. Lydekker, and the ear was relatively not quite so narrow, but the general formation was closely similar. This new example confirmed Mr. Lydekker's diagnosis of *E. a. peeli*.

Mr. J. C. White, C.I.E., C.M.Z.S., exhibited photographs of a living specimen of a young Takin (*Budorcas*) from Ghassa, N.W. Bhutan. The photograph (text-fig. 216) had been taken on board ship at Calcutta and the animal was to be presented to

Text-fig. 216.



Young male Takin (*Budorcas taxicolor whitei*).

the Society. The Secretary added that he had ascertained that the Takin had reached Genoa in good condition and might be expected at the Gardens about June 21st. It was the first Takin that had reached Europe alive.

On behalf of Mr. R. Lydekker the Secretary exhibited photographs of a spotted bull Tsaine or Bantin shot by Mr. Arthur Porter in the great forest of Siam in November 1908. The tawny-coloured hair of this bull is flecked all over with small

white spots, as is shown not only in the photograph (text-fig. 217), but by a piece of the hide presented by Mr. Porter to the British Museum. When noticing this animal in 'The Field' newspaper Mr. Lydekker suggested that the spotting might be a "sport," or due to senility; but since that date a second spotted Tsaine has been killed by Mr. Elwes, a friend of Mr. Porter, in the same forest. This considerably alters the case, although there is no

Text-fig. 217.



Spotted Bull Tsaine from Siam, photographed by Mr. Elwes.

information as to whether all adult male Siamese Tsaine are flecked with white. As no such flecking has been recorded in Burmese Tsaine (*Bos sondaicus birmanicus*), Mr. Lydekker ventured to provisionally propose the name *B. sondaicus porteri* for the Siamese Tsaine, taking the piece of hide in the British Museum as the type.

*A new Rat from Guatemala.**

Mr. Oldfield Thomas, F.R.S., F.Z.S., exhibited specimens of a new Rat which had been obtained by Mr. G. C. Shortridge during the collecting trip to Central America on which he had been

* [The complete account of this new species appears here, but the name and a preliminary diagnosis were published in the 'Abstract,' No. 73 (June 15, 1909).—EDITOR.]

recently sent by the Society. The trip had been mainly organized to obtain live animals, but it had been a definite part of Mr. Shortridge's duties to collect what study-specimens he could, and these had now been presented to the National Museum by the Society.

The species was described as follows :—

OTOTYLOMYS GUATEMALÆ.

Thos. Abstr. P. Z. S. 1909, p. 32 (June 15).

Allied to *O. phyllotis*, but considerably larger.

Fur soft and fine. General colour above uniform greyish-brown (rather browner than "mouse-grey"); back darkened by black-tipped hairs. Under surface white, not sharply defined laterally, the majority of the hairs white to the roots, but down the centre of the chest and belly many have slaty bases. Ears not specially enlarged, naked, greyish. Hands and feet parti-coloured, the centre of the metapodials slaty-brown, their sides and the digits white; in *O. phyllotis* the whole of the hands and feet are white. Tail not so entirely naked as in the allied forms, as there are a few scattered hairs along its under surface; grey above, rather paler below, not contrasted or mottled.

Skull markedly larger in all dimensions than that of *O. phyllotis*, but showing all the characters used by Dr. Merriam to distinguish that animal from true *Tylomys*. The brain-case is, however, deeper and the palatal foramina are not so large.

Molars with a low but well-marked supplementary cingular ridge running transversely across in front of the anterior cusps, a structure also found in *O. phyllotis*, but not in *Tylomys*, nor, so far as I know, in any other genus of Cricetinae.

Dimensions of the type, measured in the flesh :—

Head and body 170 mm.; tail 161; hind foot (s. u.) 28; ear 16.

Skull—greatest length 40·7; basilar length 31·5; greatest breadth 20·5; nasals 15; interorbital breadth 6·7; breadth across parietal ridges 16·2; palatilar length 16·6; diastema 11; palatine foramina 8·1 × 3·5; length of upper molar series 6·8 (in another specimen 7·2).

Hab. Tucuru, Polochie R., about 50 miles E. of Coban, Guatemala.

Type. Adult female. B. M. no. 9.6.11.13. Original number 4. Collected 24 January, 1909, by G. C. Shortridge, and presented by the Zoological Society.

This species is at once distinguishable from *O. phyllotis* by its larger size, greyer colour, and parti-coloured feet, in which respects, as in its smaller palatine foramina, it tends to approach the members of *Tylomys*. It is smaller than *O. fumeus* Allen.

Mr. Thomas expressed his pleasure that the discovery of so marked a new form had resulted from the dispatch of Mr. Shortridge to Central America, and hoped that the Society would undertake many such expeditions in the future.

The Coral Island Question.

Dr. F. Wood Jones, F.Z.S., exhibited lantern-slides, models, and specimens to illustrate the formation of coral structures. The following is an abstract of his remarks :—

The full communication upon which the demonstration was based will be reproduced in its complete form elsewhere. The present note consists merely of a brief *résumé* of the problems requiring solution, a criticism of those theories already advanced, and a proposal of some new suggestions arising out of the study of the atoll of Cocos Keeling.

(i.) The problems demanding explanation.

A theory that is to be satisfactory must not be limited in its application to any one form of coral structure, but must account for the origin of all those forms of reef and island that are built up of coral. It must take notice not only of the larger land masses, and the more obvious geographical structures, but must embrace the actual growth tendencies of the coral colonies themselves, for it is merely by an aggregation of such colonies that these structures are made up. The submerged coral bank, the barrier reef, the fringing reef, and the atoll must all receive an adequate explanation; and this explanation must be compatible with the actual processes that may be observed to take place in the individual colonies of a reef.

In the case of the atoll—the most highly developed of all the coral structures—the theory must satisfactorily account for the presence, and development, of all the several parts that enter into its composition. Finally, no explanation must be considered as adequate that carries us only to the stage of the developed atoll, for it must also agree with, and account for, the tendencies of its known after-history.

The problems connected with the development of the atoll are to be correctly gauged only from a proper appreciation of the whole of its structure. The explaining of the origin of an extensive coral reef situated upon a large ocean plateau, the mere raised rim of which constitutes dry land, is a problem different from that involved in accounting for a ring of islands, when these islands are supposed to be the summit of an abruptly rising oceanic peak.

The question of the actual contour of the elevation of the ocean floor upon which the atoll itself takes origin, is a very important one; and, in the case of the Cocos Keelings, the soundings of the cable routes have accurately determined the true proportions of this island basis. In this case, the bank that rises from the bed of the ocean is by no means a steep one, and it is only the drop from the reef edge into comparatively trivial depths that may be termed at all abrupt. For the rest, the basis consists of a gradually shelving slope of Globigerina and Radiolarian ooze

which does not reach 3000 fathoms—or ocean depths—till over 100 miles are traversed from the atoll. The summit of this long ridge is composed of Globigerina ooze, and for ten miles from the reef edge—that is to a depth of 2000 fathoms—the gradient of the bank is 1 in 5. From this point on, to a distance of 50 miles from the reef, the slope is about 1 in 80, and then for the next 50 miles or so, at 1 in 100 to the ocean depths of Radiolarian ooze. The presence of this great bank of ooze demands an explanation. Upon this submarine plateau there is a coral-reef, and it is necessary to explain how the bank becomes a suitable site for coral growth—since we know that the bathymetrical range of reef-building corals is slight; and also to account for this limitation of the extension of reef-coral life in the depths of the sea.

We know that on such banks such reefs exist below the surface of the sea, and (from the soundings of Admiral Sir J. W. L. Wharton) we also know that, before they reach the surface, their margins are raised above the level of their central area. These are Darwin's "drowned atolls," and if his theory of the development of coral structures be not accepted, any new theory must take cognisance of these basin-shaped reefs. Another typical feature is the level plateau of coral breccia that forms the barrier reef and shore platform of the atoll, and that—although it does not appear to be recognized—runs uninterrupted beneath the surface of the islands, and outcrops upon the lagoon shore. To this whole platform of consolidated coral conglomerate I have given the name of the *Breccia Platform*, for its subdivision into barrier reef, shore platform, lagoon breccia, &c. is artificial, and ignores the fact that these parts are all in continuity, being really one level stratum upon which the islands rest as mere débris piles. The *Breccia Platform* of an atoll runs as a continuous structure round the whole extent of the ring, save where the lagoon entrance exists.

The origin of the *Breccia Platform* must be made clear, and its presence as a continuous layer beneath the surface of the islands needs explanation. It is the normal state of affairs for the entrance to the lagoon to be situated upon the lee side of the atoll and this requires explanation, as do also the facts that some atolls are perfect circles with no entrance to the lagoon, while some have a pseudo-entrance to the windward.

In some atolls, each constituent island of the ring is itself an atollon and encloses its own lagoonlet; in others, certain of the islands only become atollons, or some, or all, of the islands are crescent-shaped, and are only approximations to the circular form. These conditions are obviously the outcome of the actions of forces very similar to, or identical with, those that formed the parent atoll, and the explanation of its formation should also be applicable to the cases of the constituent islands.

Observations extending over a long period of time may be recorded of several atolls, and in these cases it is usual to find

that the lagoon tends to become steadily more shallow, while the actual growth of coral upon its bottom actually diminishes. In some cases, and in certain stages of atoll development, this change takes place rapidly, so that in the human history of the atoll great alterations have taken place in lagoon configuration. Again, the lagoons of many atollons, and of some atolls, become entirely obliterated and dry land joins island to island across the ring. The theory that furnishes an explanation for the origin of these structures must not be in opposition to this known fact of their after history. Some high oceanic islands possess a reef that surrounds their coast-line and is a mere outskirts to their land; while, in some cases, the reef stands out from the shore, and a channel of shallow water intervenes between the shore-line and the reef. These features must be accounted for, for the near-shore reef and the outstanding reef are evidently very similar formations to the reef that is seen as the seaward margin of the breccia platform of atolls.

Finally, colonies of *Porites*, and other corals of a massive habit of growth, tend, with their increase of size, to become first flattened at the top and then basin-shaped,—only the outer edge of the top of the colony being a raised rim of living coral. This formation is strangely like an atoll in miniature, and its development must be carefully studied.

(ii.) *The theories put forward to explain these problems and a discussion of some observed facts that tend to contradict them.*

(a) *The Theory of Subsidence*; first brought forward by Darwin in 1837 (Proc. Geol. Soc. vol. ii. p. 552). In this theory the sinking of the land basis was the cause of all the typical features of fully developed coral structures.

The oceanic bank is assumed to be the remains of old land sunk beneath the waves. The steps of development are as follows. An oceanic island is situated in a sea the conditions of which, such as constant temperature &c., permit the flourishing of the reef-building corals. The coral colonies grow around its shores wherever the submarine slope furnishes foothold within their bathymetrical range. The island becomes surrounded by a reef. The process of subsidence causes the island to sink slowly beneath the waves. The reef continues to grow upwards, especially at its outer edge, for Darwin said that better aeration by waves, and more abundant food, nourished the outer colonies; there is no compensation for the sinking land, and the island becomes surrounded by a moat, girt about by an outstanding coral-reef. The process goes on: the land finally sinks within, and the reef—upon which islands are afterwards developed—encloses a lagoon in which the original island has disappeared. Finally, when subsidence is too rapid for the upgrowth of the coral-reef to keep pace with it, the whole structure sinks beneath the waves as a reef with raised margins—

a "drowned atoll." The theory is wonderfully complete and embraces every form of coral structure. Many observed facts have, however, been accumulated since its first proposal, and many of these observations tend to make the theory untenable.

Atolls are known to exist on land areas actually rising—"high islands" and "low islands" exist in the same neighbourhood; and some atolls bear unmistakable signs in their own structure of actual elevation having taken place during their formation. (Semper.)

The undermining of trees and the denudation of shore-lines do not necessarily indicate subsidence, for they are inconstant effects, and an area of land denudation is compensated for by an area of land construction at another part of the island ring. The lagoon does not tend to become deeper as time goes on, nor do its shores tend to become constantly denuded by their sinking beneath the waves; but lagoons tend to shoal, and lagoon shores to encroach upon the waters of the lagoon. "Drowned atolls" are not necessarily final stages of atoll sinking, for they may be early stages of atoll making.

It is not to be assumed that subsidence, like a conflagration, obliterates its own evidences, for were subsidence to have been a factor in the formation of the Cocos atoll, the *Breccia Platform* would inevitably show its workings.

Since the outer edge of the *Breccia Platform* is the most recently formed part, and its inner edge is its most ancient part; and since, in its whole extent, it embraces portions laid down throughout an enormous period of time: it is evident that the level of its outer edge should be higher than that of its inner edge, if subsidence had occurred—and this is not found to be the case.

The fact that atolls tend to be elongated along the line in which the group to which they belong is stretched (Sollas, Brit. Ass. 1893) does not necessarily indicate that subsidence has caused the sinking of a long ridge of oceanic land, for since the wind has a great influence in atoll shaping (Kramer, Hedley, &c.), the wind that shapes the individual atoll tends to shape the whole group.

(b) *The Theory of Solution*; first brought forward by Sir John Murray in 1880 (Proc. Roy. Soc. Edin. April 5th, 1880). Between the date of the publication of Darwin's theory and the framing of this hypothesis, several new observations had been made, and some of these were of such a nature as to tend to disprove the earlier theory, and some of them greatly simplified the problem. It was known that banks did exist in the sea upon which reef-corals might conveniently start their building. This knowledge was not available in Darwin's time.

In Sir John Murray's hypothesis these banks are assumed to be probably volcanic in origin and to be afterwards clothed with *Globigerina*-ooze. The reef is formed upon the bank when the bank is of a convenient depth, and the corals of the outer edge grow more luxuriantly because they are better fed. The central parts

of the reef are gradually removed by solution of dead coral-rock owing to the action of carbonic acid gas dissolved in sea-water.

The lagoon is caused by the solution of the calcium carbonate of the coral colonies within its limits, and so the atoll shape is developed.

The existence of such banks in the open ocean is, of course, undoubted, but the evidence that they are all volcanic seems to be lacking: that they are clothed with Globigerina-ooze is well known from many observations.

That carbonic acid gas in sea-water can dissolve calcareous skeletons of coral colonies and other marine animals is a well ascertained fact, but that the process forms atoll lagoons is a mere hypothesis. The work of Murray, Irvine, and Ross shows that at greater depths the power of solution of sea-water is greater than at the surface: an explanation is therefore needed for the non-solution of the base of the island bank, while the process proceeds so rapidly at lesser depths as to form deep lagoons on its summit.

That calcareous matter suspended (but not dissolved) in the sea-water is swept in great quantities from lagoon *outlets* is true, as Sir John Murray observed; but it is also true that at the *inlets* it pours into the lagoon in such quantities that in Cocos atoll Dr. H. B. Guppy (himself an advocate of the solution theory) estimated that 5000 tons of sand and débris were washed in and deposited about the lagoon margins every year.

The deposition of calcareous matter carried in *suspension* in the water takes place more rapidly in the lagoon than does its removal. It is true that coconut palms are seen to overhang the waters of the lagoon as though the shore had been dissolved from about their roots: the fallacy of this argument has long been made evident when it is used as a support for the Theory of Subsidence, and is no less evident when urged to support the Theory of Solution. It is an accurate observation that the islets on a reef are commonly situated nearer to the lagoon shore than to the seaward edge, but this is the outcome of their method of making by the waves, and by the outward extension of the reef, and does not necessarily indicate that matter has been removed from within.

If it be granted that the waters of the lagoon might be specially favourable to the action of the processes of solution: it remains to be explained why the central portions of a reef, twenty fathoms under water, are dissolved more rapidly than are the outer margins. Until this explanation is supplied, basin-shaped reefs or "drowned atolls" do not become any easier to account for. The Solution Theory is urged to account for the formation of lagoons, and to explain how they become "widened and deepened"; but the widening and deepening of lagoons is contrary to experience, for narrowing and shallowing is the common fate of lagoons.

Granting that solution proceeds rapidly in lagoons, it still must be remembered that calcium carbonate is deposited from solution in large quantities within the lagoon area. Lagoon sandstone

is entirely a product of the lagoon, and so is the lagoon conglomerate; and both of these substances depend for their construction on the deposition of calcium carbonate around particles held in close contact. Again, fragments of dead colonies that are trundled up and down the lagoon shores by every tide, are commonly made more hard and more heavy by a rich deposit of calcium carbonate in the interstices of their structure. Finally, if solution of calcium carbonate is taking place within the confines of the lagoon, its action must be a feeble one, for in the Cocos lagoon are wide areas covered by dead coral colonies, killed, as we definitely know, in 1876; and these dead masses have resisted solution during the past 30 years.

(iii.) *Suggestions put forward by the Author to explain the development of Coral structures.*

As an outcome of observations made on the Cocos-Keeling atoll, it is suggested that the process of "Sedimentation" takes the largest share in the production of most of the stages of an atoll's history. The bed of the open ocean is composed of matter that has fallen from the surface; sedimentation is always taking place all over the ocean. In certain places, sometimes owing perhaps to the influence of oceanic currents, sometimes to the presence of an already existing elevation upon the ocean bottom, this sediment will tend to make ridges or banks. Many such banks are known to exist in the depths of the sea.

What may be the nature of the original elevation that has become covered by this deposit of Globigerina and Pteropod ooze, we do not know. Whatever their original nature they become essentially "Sedimentation" banks.

The question then arises as to where beneath the surface of the sea will the building of banks by sedimentation become arrested. The answer may be partly given by determining where wave action ceases to be felt below the surface of the sea, and the data to be derived from published observations on this point show the level to be somewhat inconstant. Its variability would be confidently expected, for waves vary enormously in their size and in their power to stir the underlying water. Yet we know that there is some point between the surface of the ocean and the bottom, above which the action of waves is felt and sediment will not come to rest in open ocean, and below which there is no wave stirring and sediment may rest and build banks and raise the ocean bottom. This point is considered important; and the plane in which this line of stasis occurs is named the *limiting line of sedimentation*. It is therefore to the *limiting line of sedimentation* that banks formed by sediment may be raised. A bank so raised would rise to such a plane, but could not go beyond it, for the wave motion would keep the particles moving, and thus level out the top of the bank and flatten it, so that it formed a plateau at the level of the *limiting line of sedimentation*. It is

claimed that the bathymetrical limit of the reef-building corals is intimately associated, if not coincident, with the *limiting line of sedimentation*, and that it is therefore a variable plane depending on the local conditions of the sea. The reasons for this coincidence are to be found in the study of the living corals themselves; and I have come to the conclusion that the presence of matter suspended in the water is the most potent factor in determining the unsuitability of an environment for coral life. Where sediment is at all times liable to fall upon the living zooids, reef-corals will not flourish: we would therefore not look for their luxuriant presence below the *limiting line of sedimentation*. In the wave-stirred area above this line, however, they can and do flourish. We therefore arrive at the presumption that sediment can build banks up to this hypothetical line, and reef-corals can build banks from this line up to the surface of the sea. There is therefore no reason why coral colonies should not settle upon the bank and start the development of a reef. As a matter of fact several other forms of life that possess calcareous skeletons outrun the reef-corals in bathymetrical range, and it is likely that they (calcareous algae, deep water corals, &c.) first populate the summit of the bank.

The process now becomes less a matter for hypothesis and more one for actual observation, for the growth tendencies of reefs and of colonies may be more easily studied. It is claimed that the tendency is for such reefs to become "basin-shaped reefs," and to develop as flat banks, with edges raised from their general surface and abundantly covered with coral colonies. The chief factor in this process is again the action of sedimentation. The surface waters still drop their burden of suspended matter over the reef, and it is deposited upon the uneven surface of the coral colonies, for, though it could no longer come to rest upon the open sedimentation bank, it more easily finds a lodgment upon the broken coral surface of the reef. At the edges of the reef the sediment becomes more easily washed off by wave action, and the corals of the circumference of the reef flourish most.

To obtain a concrete picture of the process it is only necessary to turn to the colonies to be found any day in quiet pools in which sediment is accumulating. A colony of *Porites* grows as a spherical mass. In time it develops to such a size that its rounded upper surface becomes sufficiently flat to afford a lodgment for sediment. Then the activity of its central zooids wanes, and, by the upgrowth of the peripheral ones, the flattening increases. At length the central area dies—the zooids choked by sediment,—and a raised ring of active living zooids surrounds a central depressed area—an atoll in miniature.

That this process is not due to the colony reaching tide-level (Darwin, Semper) is proved by the abundant finding of such colonies developed many feet below the level to which the tide ever falls.

The process that may be seen any day in the myriad colonies

around an atoll, is presumed also to occur on the reef as a whole, for it is merely a question of substituting colonies for individual zooids to picture the development of the submerged basin-shaped reef.

The basin-shaped reef continues to grow upwards until tide limit arrests the growth of its margins. At this stage the waves begin to act upon it and hammer fragment against fragment with the production of a quantity of coral débris at the point of maximum intensity of the waves. This débris becomes cemented into solid breccia by the deposition of calcium carbonate around the particles that compose it. This is the beginning of the breccia platform, and its origin may be looked for upon the windward side; and on that side it will always remain best developed.

The breccia platform follows the raised rim of the reef in its development, and forms a level, solid, conglomerate crescent, upon which the waves break at low tide. Upon this platform some waves of unusual violence will hurl fragments broken from the reef margin, and these masses will be left stranded upon the platform when the force of the waves can trundle them no further.

This is the beginning of the island, and this process also may be expected to originate at the windward side and to be always most perfectly developed there. Any fragment thrown upon the breccia platform is potent to bring about an important change, for it initiates a process that may be seen anywhere when an obstacle is placed in the line of a current of water that carries any sediment in its stream. The current impinges on the impediment and its burden of sediment is deposited in stream lines from its extremities (Hadley and Dr. Guppy). In this way the form of the island tends to become that of a crescent.

The piling up of fragments will follow the line of the breccia platform, and so will take place as a part of the circumference of a circle or a horse-shoe. At the lee side, the waves will not have sufficient force to construct a breccia platform or pile débris upon it, so the lagoon entrance is situated upon this side. When the wind blows in opposite directions for two definite seasons, as in the Monsoon area, the action may be equalised all round the reef-edge, and so the atoll be a completed ring and each of its constituent islands be perfect atollons. In the Trade area, however, the uniformity of the wind will produce a horseshoe-shaped atoll, elongated in the line of the wind, with crescentic islands on its windward side. When the atoll structure is once developed, the enclosed lagoon tends to become the resting-place of a vast amount of sediment, formed by the disintegration of coral fragments by the force of the waves. The method of the deposition of this sediment is important.

As waves rush over the breccia platform in the intervals between adjacent islands, the current becomes slowed at the sides of the inlet, and sand is deposited in stream lines from the extremities of the islands, helping to increase more and more their crescent

form. In the middle of the interval between two islands the inrushing current sweeps on farthest, and its burden of sand is dropped in the lagoon *opposite the gap in the island ring*.

This process accounts for the existence of those atolls that have the most land upon their leeward side, and an entrance *guarded by a breccia platform* upon their windward side. The sand swept in at their windward side is deposited upon the lee side of the lagoon (if it be a small one) and comes to rest in the original lagoon entrance. The entrance becomes blocked up, and a wide belt of land is formed upon the lee side of the atoll; but no barrier reef exists upon the lee side.

As sand is deposited in the lagoon it tends to obliterate the coral growth, and so a lagoon, that at first tended to become shallow by the upgrowth of coral colonies, ultimately becomes devoid of living coral, and to shoal entirely by the deposition of sediment. In the Cocos-Keeling atoll, the history since 1825 shows a steady filling-in of the lagoon. The continuation of the process that formed the perfect atoll, therefore, tends to obliterate the lagoon. The lagoon shores gain on the lagoon water, and banks rise up in its shallower parts; the windward side of the lagoon, if it be of large size, being the first portion to become obliterated.

The explanation of the origin of fringing reefs follows the same lines. On *any* platform that lies above the *limiting line of sedimentation*, reef-corals will develop, when the conditions of the water are suitable. Fringing reefs are merely reefs taking origin upon the submarine slopes of oceanic land, when these slopes afford a foothold in the wave-stirred area.

Barrier-reefs were explained in 1856 by Prof. Le Conte as being fringing reefs of which the growth was "limited on one side by the muddiness of the water, and on the other by the depth." In 1884 Dr. Guppy independently furnished the same explanation. This explanation, which is an isolated and discordant thing when "Subsidence" or "Solution" is taken as accounting for atoll formation, becomes of consequence, and falls into line with other ascertained facts, when the importance of "Sedimentation" is appreciated.

Dr. R. Broom, C.M.Z.S., exhibited an unborn foetus of *Chrysochloris hottentota*, and two young specimens of *C. asiatica*, one probably only a couple of days old, and made some remarks on the habits and life-history of the Cape Moles.

Dr. R. Broom, C.M.Z.S., also exhibited the skulls of two South African fossil reptiles—*Lycosuchus vanderrieti* and *Bauria cynops*. The former is from the Karroo Beds of Middle Permian age, and is the most perfect Therocephalian skull as yet discovered.

Since Owen's order Theriodontia was found to contain two well-

marked groups of mammal-like reptiles, it has become necessary to subdivide the group, forming either two new orders or two sub-orders. The older group, which is confined to Permian beds, has a single occipital condyle and a Rhynchocephalian palate, and has been named Therocephalia. The other group, which is restricted to Upper Triassic beds, has two occipital condyles and a mammal-like secondary palate, and usually complex molars. This group should retain Owen's original name Cynodontia. Doubtless the later group is descended from the earlier, and *Bauria*, though a Cynodont, to some extent forms a connecting link. The Cynodonts are of exceptional interest, as there is little doubt the mammals have arisen from one of the members.

The following papers were read:—

1. On the Organ of Jacobson in *Orycteropus*.

By R. BROOM, D.Sc., C.M.Z.S.

[Received June 3, 1909.]

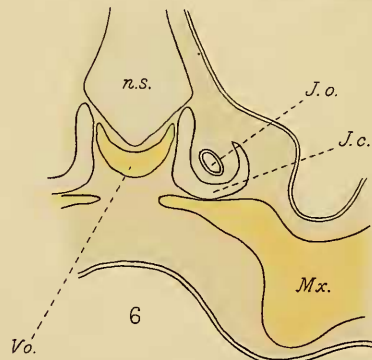
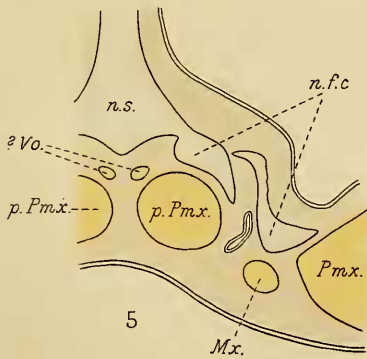
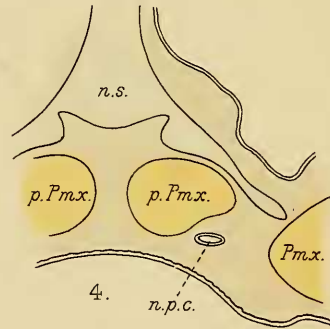
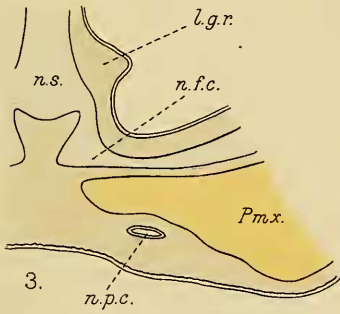
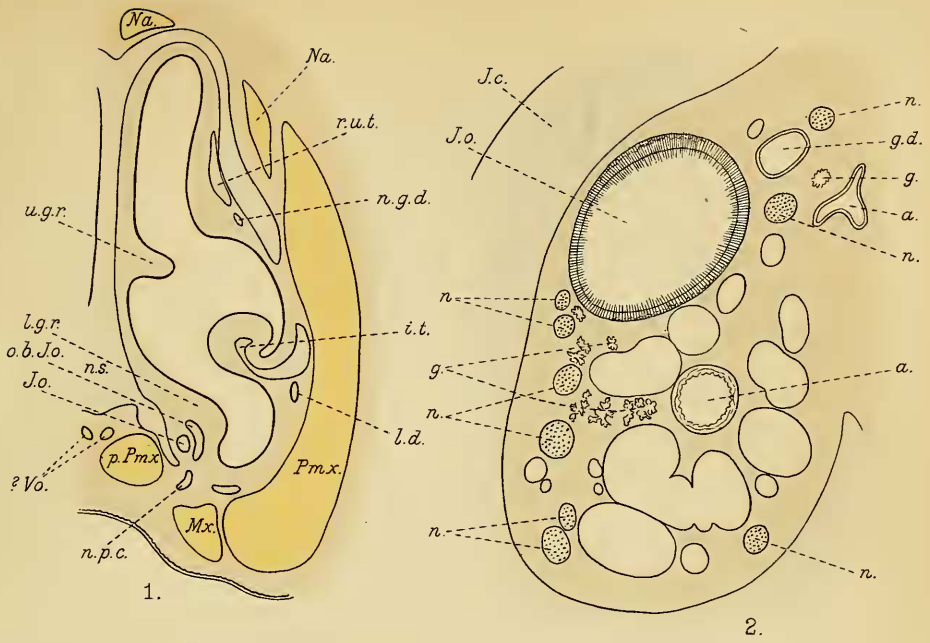
(Plate LXXI.*)

About 1898, in studying the comparative anatomy of the organ of Jacobson in Mammals, I observed that throughout whole groups the structure and relations of the organ varied very little, and that as the organ seemed to be less affected by change of habits than almost any other, it was of great importance in revealing the obscured affinities of aberrant forms. It was seen that, notwithstanding the enormous differences in most points between the Ungulates, the Carnivora, the Chiroptera, and the Insectivora, the same type of organ is found in all, while a markedly different type is found in all Rodents, and a third type in *Dasypus*. When the aberrant *Macroscelides* was examined, it was found that the organ was not at all like that of the normal Insectivores but almost typically Marsupial, showing that though for convenience the Elephant-shrew is placed with the Insectivora it has probably little real affinity with them.

Owing to the apparently isolated position occupied by *Orycteropus*, as shown by its dentition and numerous other characters, I had long been anxious to examine its organ of Jacobson, but it is only quite recently that I have had an opportunity of so doing, when, through the kindness of Dr. Péringuey, of the South African Museum, I obtained the head of a recently born specimen.

The organ and its relations have been studied by means of transverse sections, so that a comparison is easily made with the large number of other mammals in which the organ has been similarly studied.

* For explanation of the Plate see p. 683.



Owing to the absence of well developed incisors the pre-maxillary bone is feeble and the palatine papilla far forward. The papilla is rather small and has no trace of a supporting cartilage. The naso-palatine, which is unusually long and passes for some distance nearly directly backwards, opens by the side of the papilla.

A transverse section through the plane of the papilla shows the nasal cavity completely surrounded by cartilage, the nasal septum below being continued into the nasal-floor cartilage and this laterally into the alinasal.

Fig. 3 on Pl. LXXI. shows a section a little behind the papilla. The nasal-floor cartilage is here seen still attached to the nasal septum but distinctly specialised. The lower glandular ridge of the septum (*l.g.r.*) is seen cut across. The premaxilla has not yet given off its palatine process. The naso-palatine canal is seen under the inner part of the premaxilla.

Fig. 4 is some distance behind fig. 3. The nasal-floor cartilage is free at its outer edge from the alinasal, and the palatine process is now seen distinct from the premaxilla.

Fig. 5 is only a short distance behind fig. 4. The naso-palatine canal is seen curving up to open into the organ of Jacobson, and the nasal-floor cartilage is dividing into an inner and outer part. The palatine process of the premaxilla is of large size. Above and to the inner side is a small ossification which may be the remains of the prevomer. It is, however, very closely connected with the anterior end of the true vomer and may have no morphological significance. The anterior end of the maxilla is seen between the premaxilla and its palatine process.

Fig. 1 is a section across the whole nasal cavity a very short distance behind the plane of fig. 5. The premaxilla is seen to be well developed. At the upper part of the section the anterior part of the nasal is shown, both parts of the bifurcated end being seen. The nasal septum is slender and the alinasal continued round the upper and outer part of the cavity. The inferior turbinal is cut across near its anterior end. On the inner side of the alinasal is a small plate of cartilage (*r.u.t.*) of doubtful significance. It is not attached to any other cartilage and would appear to be a rudimentary superior turbinal. Near the middle of the nasal septum is seen a well-developed upper glandular ridge which runs along the septum. The nasal-floor cartilage is now seen in three portions, the middle one of which is the outer bar of Jacobson's cartilage. The anterior end of the organ is seen cut across, and below it the naso-palatine canal passing on to the nasal cavity.

A little behind this plane the outer bar is seen uniting with the base of the inner part of Jacobson's cartilage and giving rise to the V-shaped section seen in fig. 6.

Fig. 6 shows the condition much behind fig. 1, and near the middle of the organ.

Fig. 2 is a more enlarged figure of the organ and its related

structures taken some little distance behind fig. 6. It will be seen that in both figures the organ is oval in section and that the ciliated epithelium is found all round, the most specialised portion being on the upper and inner sides. The greater part of the cartilaginous groove is filled by a huge venous plexus quite irregularly arranged. There is a fairly large artery, numerous nerves and a little glandular tissue. On passing further back the gland-tissue becomes much more abundant and the organ becomes reduced to a narrow duct. Jacobson's cartilage near the posterior end is reduced to a flat plate.

In the relations of the organ perhaps the most striking point is the absence of any developments of the nasal-floor cartilage to support the naso-palatine canal. Thus *Orycteropus* differs from all the Eutheria except the Edentata as exemplified by *Dasypus*, and the aberrant Insectivore *Macroscelides*. Even from the primitive Ungulates such as *Procavia* or *Sus* it differs so greatly as to suggest that any supposed Ungulate affinities must be extremely remote.

The Rodents form, so far as the organ of Jacobson is concerned, a group by themselves, but this group also must be very remote from *Orycteropus*. We are thus forced to seek for the affinities among the more primitive mammals—the Edentates, Marsupials, and Monotremes.

Besides agreeing with these early mammals in the absence of cartilaginous developments for the support of the naso-palatine canal, it further agrees with them in having preserved the outer cartilaginous bar which is probably the remains of the turbinal of the organ.

In the Edentata the organ has been described only in *Dasypus* and a few notes have been made in the case of *Manis*. *Dasypus* differs entirely from *Orycteropus* in having the organ opening into the nasal cavity and not into the naso-palatine canal and in many other details. *Manis* agrees with *Orycteropus* in having a long naso-palatine canal and in the organ opening into it, but in the absence of figures or detailed description it is impossible at present to say how far the agreement extends.

On the whole the condition in *Orycteropus* comes nearest to that in the Marsupials, but there are many points of difference, of which the most important are (1) the absence of the papillary cartilage, and (2) absence of a cartilaginous support to the lower glandular ridge. Less important are the shape of the organ, its mode of opening into the naso-palatine canal, and the very irregular venous plexus. In the structure of the nasal-floor cartilage there is some resemblance to *Echidna*, but this latter has the organ and its cartilages so much better developed that comparisons become difficult.

The evidence from the study of this region would seem to point to *Orycteropus* being descended from a line of ancestors the earlier members of which were probably allied to Marsupials, whilst the later members branched off from the Eutherian stem before any

of the higher Eutherian types had been specialised. If the *Orycteropus* line ever coincided with that of *Dasyppus* the two must very early have diverged.

My thanks are due to Dr. Péringuey for the specimen, and to Prof. Graham Kerr for the use of his laboratory while making the sections.

References to Literature.

- R. BROOM.—“A Contribution to the Comparative Anatomy of the Mammalian Organ of Jacobson.” Tr. Roy. Soc. Edin., 1898.
 R. BROOM.—“On the Comparative Anatomy of the Marsupial Organ of Jacobson.” Proc. Linn. Soc. N. S. W., 1897.

EXPLANATION OF PLATE LXXI.

Fig. 1. Transverse section of snout of *Orycteropus afer*. × 5.

Fig. 2. Transverse section of Organ of Jacobson of *Orycteropus afer*. × 40.

Figs. 3-6. Transverse sections of lower part of snout of *Orycteropus afer*. × 7.

a., artery; *g.*, gland; *g.d.*, gland-duct; *i.t.*, inferior turbinal; *J.c.*, Jacobson's cartilage; *J.o.*, Jacobson's organ; *l.d.*, lachrymal duct; *l.g.r.*, lower glandular ridge; *M.x.*, maxilla; *n.*, nerve; *Na.*, nasal; *n.p.c.*, naso-palatine canal; *n.s.*, nasal septum; *o.b.J.c.*, outer bar of Jacobson's cartilage; *P.m.x.*, premaxilla; *p.P.m.x.*, palatine process of premaxilla; *r.u.t.*, rudimentary upper turbinal; *u.g.r.*, upper glandular ridge; *V.o.*, vomer.

2. On some Points in the Structure of the Lesser Anteater (*Tamandua tetradactyla*), with Notes on the Cerebral Arteries of *Myrmecophaga* and on the Postcaval of *Orycteropus*. By FRANK E. BEDDARD, M.A., F.R.S., F.Z.S., Prosector to the Society.

[Received May 20, 1909.]

(Text-figures 218-225.)

In April of the present year I dissected an example of this Edentate in which the blood-vessels were filled with blood, and which was so little diseased that all the viscera and their connecting ligaments were in a perfectly normal state. The excellent condition of the animal led me to take comprehensive notes concerning the principal viscera; and as there are still some lacunæ in the published accounts of the anatomy of this little Anteater, and a few organs have not, so far as I can ascertain, been examined at all, I have prepared a short account of such facts as appear to me to be new. Although the anatomy of *Tamandua* has not up to the present been exhaustively studied, we are in possession of a good deal of knowledge concerning its structure. Duvernoy*,

* Mém. Soc. Hist. Nat. Strasbourg, 1830, vol. i. This memoir is only descriptive of the tongue of *Tamandua* (and of the tongues of some other animals, e. g., *Echidna*, *Chamaeleon*).

Chatin *, W. A. Forbes †, Rapp ‡, and Flower § have dealt with various points in its anatomy, the first three having occupied themselves chiefly with the salivary glands, tongue, and associated structures, while Flower has given in his well-known lectures at the Royal College of Surgeons a general account of the alimentary canal in which a number of facts are mentioned for the first time. A good many anatomical details are given in the monograph of Rapp; but only the external form, the skull, and the tongue are figured by that anatomist. In fact it is the tongue and the salivary glands which have engaged the attention of most of those who have occupied themselves with the structure of this Edentate. As to the intestine, the folds which are so characteristic of this animal and *Myrmecophaga* are apparently not mentioned by Rapp. He does refer, however, to the fine network of a more minute character which is formed by the mucous membrane of the intestine. Of this he remarks that it cannot be altered by stretching the gut. I shall refer in the proper place more particularly to the memoir of Hyrtl || upon the arterial system, who figures the arteries of the brain and of the limbs. The results obtained by Hyrtl from his examination are referred to by Tandler ¶ in his important memoir upon the arteries of the brain in a series of mammals. The placenta of *Tamandua* is described by Milne-Edwards **. I have myself †† referred to the alimentary canal of this Edentate, which is formed upon a simple plan like that of certain other lower mammals, the continuous mesentery of the reptiles being preserved without any of the secondary connections which are found in most other mammals. The gut had been also, and previously, described by Mitchell ‡‡. The muscular anatomy is fully described by Windle and Parsons §§, who quote previous literature. It is noteworthy that these authors, although they naturally include *Tamandua* and *Myrmecophaga* in the same family, find, nevertheless, some myological differences between them.

The brain is described by Elliot Smith |||, and some of its arteries by myself ¶¶. Upon this matter I have an additional observation to make, and am able to compare the arterial system of the brain in the genus *Tamandua* with that of *Myrmecophaga*. The specimen of *Tamandua* which I described is in the Museum of the Royal College of Surgeons. I have now some notes to offer upon a second example, which died in 1905, and of which the brain was

* Ann. Sci. Nat. (5) xiii.

† "On some points in the Anatomy of the Great Anteater (*Myrmecophaga jubata*)," P. Z. S. 1882, p. 287.

‡ 'Die Edentaten,' Tübingen, 1852.

§ Medical Times and Gazette, 1872.

|| Denkschr. k.-k. Akad. Wien, vi. 1854.

¶ *Ibid.* lxxvii. 1898.

** Comptes Rendus Acad. Sci. Paris, lxxiii. 1871, p. 1386.

†† P. Z. S. 1908, p. 570.

‡‡ Trans. Z. S. xvii. 1905, p. 455 & p. 457, fig. 11.

§§ P. Z. S. 1899, pp. 314 & 990.

||| Cat. Phys. Series Mus. Roy. Coll. Surgeons, vol. ii. 2nd ed. (London, 1902) p. 288; and Trans. Linn. Soc. vii. 1899, p. 293.

¶¶ "On the Arteries at the Base of the Brain in certain Animals," P. Z. S. 1904, vol. i. p. 188.

injected. I am able to compare this brain with that previously described. It is interesting to notice that there are no important differences between the two brains in respect of their arterial system, which tends to inspire confidence in the fixity of this character. The rhomboidal space at the end of the medulla, formed by the division and subsequent reuniting of the basilar artery, was identical in the two specimens. In his figure of the cerebral arteries of this animal, Hyrtl* has not represented the space referred to; so that there may be some variation. He has, however, noted—and I find that the second specimen examined by myself agrees with that figured by Hyrtl and with that figured by myself †—that the anterior communicating artery gives off a strong forwardly-running branch, which immediately loses itself between the hemispheres as the callosal artery. I shall refer to some further details in considering the corresponding arteries in *Myrmecophaga jubata*, of which I possess a well-injected brain. The cerebral arteries of this species have been described and figured by Pouchet ‡. This paper is not referred to by Tandler § or M^{lle} de Vriese ||, who have mentioned a great many other important papers upon the cerebral arterial system of the Mammalia. I find myself in general agreement with Pouchet's figure, though my specimen shows some differences from the individual studied by the French anatomist. I find that the circle of Willis is distinctly hourglass-shaped—more markedly so than in *Tamandua*. The carotids enter at the "waist" of the hourglass, as among Artiodactyles, where the circle of Willis has, as is well known, the same hourglass-shape. Anteriorly the arch of Willis is completed by the anterior communicating artery. This runs perfectly straight across the intervening space, and gives off no strong callosal artery like that of *Tamandua*. There are only some quite small branches. The Sylvian arteries (or middle cerebrals) arise from the circle of Willis asymmetrically. The right-hand artery arises exactly opposite to the anterior communicating artery; the left-hand artery (which arises by two roots, which immediately join) is behind the corresponding point on the left side. Between these arteries and the posterior cerebrals are two smaller arteries, on each side, of which the first arises just behind the exit of the carotids. The latter artery (on the left side only; there was not enough of it preserved on the right to permit of a statement) gives off immediately before it reaches the circle of Willis an artery running anteriorly, which I take to be the ophthalmic artery. The posterior cerebral arteries are rather asymmetrical, as will be seen from an inspection of text-figure 218 (p. 686). On the right side there is only one large artery, which, however, very shortly divides into two branches. On the left side three fair-sized arteries,

* Beiträge z. vergleichenden Angiologie, v.; Denkschr. k.-k. Akad. Wien, vi. 1854, p. 21, pl. iv.

† P. Z. S. tom. cit. p. 189, text-fig. 19.

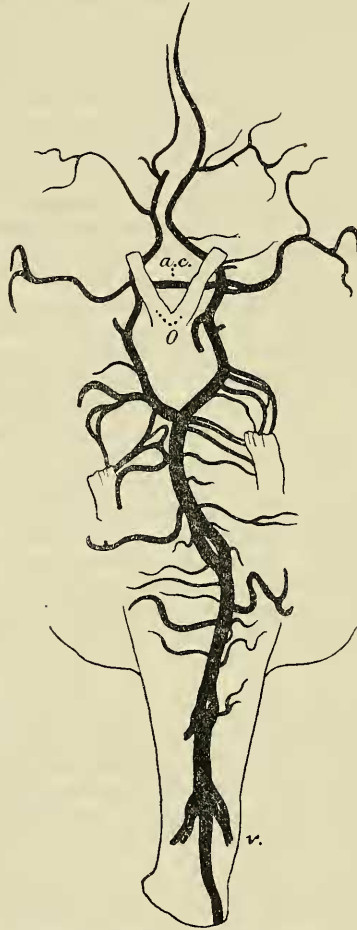
‡ 'Mém. sur le Grand Fourmilier,' Paris, 1874, pl. xiv. fig. 1.

§ Denkschr. k.-k. Akad. Wien, lxvii. 1898.

|| Arch. de Biol. xxi. 1904, p. 449.

of which, however, the anterior is considerably the larger, correspond to this. There is also here an asymmetry in the origin of the arteries, the chief artery of the left side arising anteriorly to the single posterior cerebral artery of the right side. The anterior

Text-fig. 218.

Cerebral arterial system of *Myrmecophaga jubata*.

a.c. Anterior communicating artery. *O.* Optic nerves. *v.* Vertebral arteries.

cerebellar arteries are also asymmetrical, thus contrasting with the arrangement met with in *Tamandua*. The right artery arises from the circle of Willis; the left arises just at the junction of the

basilar artery with the circle of Willis. The basilar artery of *Myrmecophaga jubata* is represented by Pouchet as having three spaces, where the artery divides and then shortly rejoins, instead of the single area of this kind which exists in *Tamandua* and which I have figured in the paper upon the cerebral arteries of mammals to which I have already referred. He also figures the basilar artery as remaining of considerable calibre for two or three inches down the spinal cord. The brain in my possession has not a sufficiently long piece of spinal cord attached to it to show the end of the wide region of the basilar artery. But it is nearly as long, and reaches as far as between the influx of the last two pairs of arteries figured by Pouchet. I imagine that the point where the basilar artery suddenly alters its calibre and receives two lateral arteries is really to be regarded as the junction of the basilar with the anterior spinal, and that the two lateral arteries are vertebrals. In that case the suggestion which I formerly made with regard to *Tamandua* will be wrong, and the space included along the course of the basilar artery will not be due to the anterior bifurcation of the anterior spinal artery to meet the two vertebral arteries, such as I have figured for example in *Chinchilla lanigera* *. There will be in both these genera (*Tamandua* and *Myrmecophaga*) a basilar artery which retains either in one place only (*Tamandua*) or in more than one place a trace of being primitively a double vessel. Pouchet finds three of these double tracts of the anterior spinal †, of which he represents the first as lying immediately behind the circle of Willis. In my specimen the first of these double tracts lay just behind the Pons Varolii, and the second, which was very inconspicuous, at the extreme end of the medulla. Just in front of the first double tract arise the middle cerebellar arteries, which are symmetrical. They arise in front of the sixth nerves. The posterior cerebellar arteries, which are not symmetrical, lie between the first and second of the duplicatures of the basilar. Further back still the basilar receives two arteries on either side, which anastomose as is shown in the annexed figure (text-fig. 218, v). These are, as it appears to me, the vertebral veins, in which case this is the end of the long basilar.

§ Alimentary Canal.

The general form of the *Stomach* in this Anteater is, as known, like that of the Great Anteater, *Myrmecophaga jubata*. I may, however, mention that the entire length of the stomach, measured in a slightly oblique line owing to the form of the pyloric region, was 85 mm., of which 35 mm. belonged to the pyloric part. The breadth of the stomach—*i. e.*, the diameter parallel with the long axis of the body—was 68 mm. The thickness of the walls of the

* *Loc. cit.* fig. 16, p. 184.

† I hardly know where to delimit the basilar from the anterior spinal.

gizzard-like pylorus was at least 12 mm., a thickness which is quite as great as that of the other Anteater, I imagine.

The *hepato-gastric ligament* or *lesser omentum* presents one or two features of interest. The greater part of this ligament was, as in other mammals, horizontal in direction, roofing-over that section of the cœlom which communicates with the larger section of the abdominal cœlom by the foramen of Winslow. The edge of this hepato-gastric ligament, lying just over the foramen of Winslow, was raised into a deep vertical membrane fully three-quarters of an inch deep, which passes dorsally of the right central lobe of the liver. This is of course all part of the lesser omentum or hepato-gastric ligament; but the vertical part seems to me to represent the primitive ventral mesentery, connected directly with the middle line of the ventral parietes and not *via* the liver. The *greater omentum* is but little developed and, as Flower has mentioned, is not attached to the colon anywhere; it is indeed not visible when the animal is opened for dissection, being covered by rather than covering the coils of the intestines. The *splenic omentum* is short, and just laps loosely over the pancreas. It can be stretched out straight quite easily, and is inserted on to the œsophageal border of the stomach, along which runs one of the important gastric branches of the portal. It connects the pancreas and the spleen with this region of the stomach. A remarkable fact about the stomach of this Edentate is the large number of lymphatic glands which are found in the region of the stomach and, as I shall explain later, of the intestine. As to those which occur in the region of the stomach, there are first of all three, one above the other, which lie on the side of the junction between duodenum and stomach—that side which faces the abdominal cavity. These glands are in close connection with the portal branch, which passes from the œsophageal border of the stomach to join the main portal trunk as it passes dorsally to the duodenum on its way to the liver. Two other lymphatic glands lie in the lesser omentum, one near to the œsophagus and the other close to the vertical membrane already described. Finally there are two other lymphatic glands on the pancreas side of the vertical membrane—to the right, therefore, of the expanse of membrane which connects the stomach with the liver and may be termed, and is termed, lesser omentum. An eighth gland is partly imbedded in the tip of the pancreas, where it runs towards the liver in close connection with the cystic duct of the gall-bladder.

The *Small Intestine* in my specimen measured at least 97 inches in length. This is rather understating the length, I imagine, for I was anxious not to stretch it unduly. Sir W. Flower gives 100 inches as the length of the small intestine in the example measured by himself. In the latter example of *Tamandua* the colon was only $5\frac{1}{2}$ inches long; I found that from the cæcum to the anus was quite 7 inches in my specimen. Sir W. Flower remarks that the duodenum has no mesentery attaching it to the

dorsal middle line; and I also have failed to find this duodenocaval ligament, as I suppose that mentioned by Flower to be.

Flower has called attention to the fact that this Anteater, like *Myrmecophaga*, possesses a ventral longitudinal fold in the jejunum and ileum, which is a fixed fold and cannot be obliterated by stretching the walls of the gut. I have examined this structure carefully in *Tamandua*, and am able to give a rather more detailed account of it than was given by Flower. In the duodenum there is some longitudinal corrugation of the walls of the gut. But the continuous ventral "typhlosole" does not commence until about 35 inches behind the stomach. In front of this the fold is occasionally seen to the extent of about an inch. The fold is not absolutely continuous from its commencement 35 inches below the stomach. There are two slight gaps at first, two or three fourths of an inch wide. Thereafter this typhlosole is quite continuous as a conspicuous raised fold for a distance of 28 inches. There are in this tract occasional and short branches of the fold, and also short subsidiary and parallel folds. The main fold is fairly deep and very conspicuous. Then follows a gap of 7 inches, where the internal surface of the intestine is smooth. After this there is a tract of 20 inches where the typhlosole is again visible; but it is here, except indeed for very short distances, not nearly so well-marked as it is anteriorly, and there are more subsidiary folds and anastomosing branches. The different appearance will be readily gathered from an inspection of text-fig. 219 (p. 690), which represents pieces from different regions of the small intestine. The rest of the ileum, 7 inches in length, has not any ventral typhlosole. It is clear from the descriptions of both Owen* and Forbes† that the arrangement of this typhlosole in *Tamandua* differs in detail from that of *Myrmecophaga*. For both of these anatomists write of a continuous fold throughout the ileum which, according to Forbes, occupies 15 feet 3 inches out of a total intestinal length (of the small intestine) of 24 feet 10 inches. In front of this are at intervals detached tracts of this typhlosole-like fold. In *Tamandua*, on the other hand, the fold is best developed and continuously so in the middle region of the small intestine.

In writing of the intestinal coil of Mammals‡ it had escaped my attention that Sir Richard Owen had already referred to the "Reptilian" character of the gut of *Myrmecophaga*, though I duly noted that Sir W. Flower had described the condition of the gut in that Edentate. It is possible that Flower's statement was taken from Owen's paper, to which he referred. Owen wrote of *Myrmecophaga*§ that "one common duplicature of peritoneum, continued from the middle of the back part of the abdomen, and 18 inches in extent where it is broadest, at the junction of the ileum with the colon, supports the whole intestinal canal, as in

* Trans. Z. S. vol. iv. p. 122.

† P. Z. S. 1908, p. 570 footnote.

‡ P. Z. S. 1882, p. 290.

§ Trans. Z. S. iv. p. 121.

most reptiles—mesentery, mesocolon, and mesorectum being one and the same fold." I can confirm my former statement that *Tamandua* agrees in this particular, a confirmation being important in view of the fact that this condition of the gut appears

Text-fig. 219.

b. d.Three pieces of small intestine of *Tamandua tetradactyla*.

The upper figure is a portion of the duodenum showing papilla of bile-duct (*b. d.*) and absence of "typhlosolar" fold. The two remaining figures are from the jejunum, and the "typhlosole" (*f*) is present.

to vary in *Centetes*. I take this opportunity of adding that in an example of *Myrmecophaga jubata* dissected subsequently to the date of my paper quoted below, there was no ligamentum]cavo-

duodenale. The gut was in fact quite "Reptilian." Owen has remarked* upon a huge mesenteric gland 16 inches long which lies parallel with the puckered coils of the small intestine, on the rectal side of which, and therefore parallel to it, lies a row of detached glands. I find a quite similar series of glands in *Tamandua tetradactyla*. There is one gland more or less crescentic in shape which extends from close to the pancreas anteriorly to near the commencement of the colon posteriorly. Besides this there is a chain of detached glands seven or eight in number which lie to the colic side of the large gland and are also disposed in a crescentic form, thus following the curves of the large gland. All these lymphatic glands are dark in colour, as Owen states them to be in *Myrmecophaga jubata*. The number of the smaller glands is not stated in *Myrmecophaga*. The detailed agreement between the two Anteaters is, however, remarkable, even if the exact number of the smaller glands does not tally in the two cases.

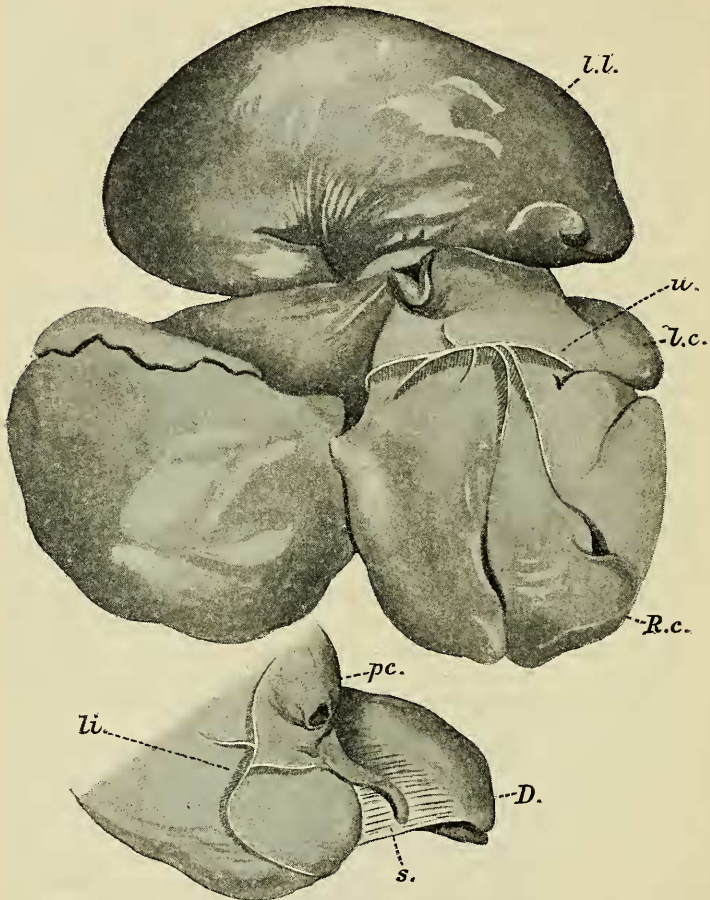
The *Liver* is, as Sir W. Flower has pointed out, like that of *Myrmecophaga* in the disposition of the lobes. I may mention that when this viscus is viewed from the diaphragmatic aspect it is seen to consist of three definite lobes only; for the right and left central are not so definitely distinguishable from each other on this view as are either the left lateral or the right lateral from the conjoined centrals. The falciform ligament shows a peculiarity which I have not observed elsewhere. It divides (see text-fig. 220, p. 692) of course the right and left central lobes, marking the central fissure of the liver. It gives off three seams which traverse the surface of the liver, of which two, those on the right side, run to the clefts separating the right central into three subdivisions, one of which is the cleft in which lies the gall-bladder. The third seam arises in front of these, and passes to the left just above the end of the cleft which separates the left central from the left lateral lobe. On the under (abdominal) surface of the liver there is a series of membranous seams visibly connected with ligaments in the same way.

The edge of the right lateral lobe of the liver is fixed down to the diaphragm, just in front of the suprarenal body, by a sheet of membrane which towards the median side slightly covers the suprarenal body, and is attached to the postcaval vein. This part of the ligament is of course the equivalent of the hepatocaval membrane of other mammals. This membrane is continuous with a semicircular seam which, as it were, cuts off a semicircular piece from the lower part of the right lateral lobe of the liver. On the median side (*i. e.*, the left side) this seam gives off a branch which runs forward and to the left, and branches once or twice on the caudate lobe. The latter lobe splits into two at its connection with the entering postcaval vein, and it is here closely adherent to that vein. It should be mentioned also that the

* *Loc. cit.* p. 121.

gall-bladder is just visible on the diaphragmatic surface of the liver. The ductus choledochus, which receives the pancreatic duct just before its entry into the duodenum, is not specially dilated, as I have found it to be in *Myrmecophaga*, before its

Text-fig. 220.

Liver of *Tamandua*.

The upper figure represents the diaphragmatic surface of the organ.

u. Umbilical ligament with its branches. *l.c.* Left central lobe of liver. *l.l.* Left lateral. *r.c.* Right central.

The lower figure represents a portion of the right lateral lobe showing the seams (*li.*) described in the text.

D. Diaphragm. *pc.* Postcaval vein where it enters liver. *s.* Ligament running from liver to diaphragm, which bears, as is shown in the figure, the suprarenal body.

termination on the extremity of a long low fold of the duodenal mucous membrane which has a recess (text-fig. 219, *b.d.*, p. 690) round the opposite extremity. It is about 2 inches from the pylorus.

The *Spleen* is rather different in form from that of *Myrmecophaga*, and is represented in the accompanying figure (text-fig. 221), which will serve in lieu of an elaborate description. It is nearly of the form of an isosceles triangle with a base line of 84 mm.; the two sides measure respectively 54 mm. and 67 mm.; the shorter side lying to the left of the body has two rounded lobate projections.

Text-fig. 221.



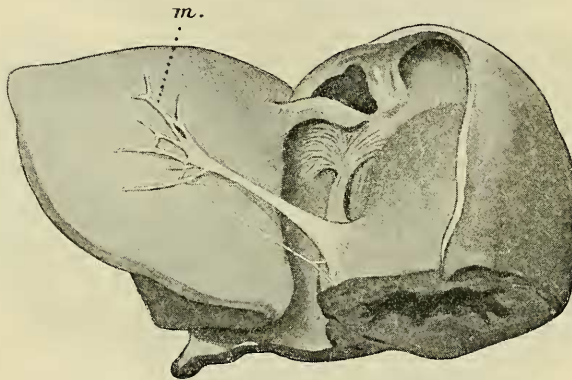
The spleen of *Tamandua tetradactyla*.

The *Pancreas* from the duodenum to the spleen is 4 inches in length; on the other side of the duodenum it extends a long way towards the liver. A lieno-caval ligament arises from the edge of the spleen and is attached along the posterior border of the pancreas for about half of the length of the latter; it is not inserted anywhere upon the left kidney. Arching over and nearly concealing the left suprarenal body, it is inserted upon the postcaval vein of its side, and can be traced down that vein and along the spermatic vein right down to the left testis, on which it ends.

§ *Heart and Vascular System.*

The cavity of the right ventricle of *Tamandua* showed two interesting features which deserve comment. There is, in the first place, a very strongly developed moderator band which is represented in the annexed text-figure (text-fig. 222). This consists of a somewhat slender muscular band which arises just below the great septal papillary muscle of the auriculo-ventricular valve. The muscular band from the septal wall of the ventricle enters this moderator band from above. On the posterior side it seems mainly formed as a process of the endocardial lining. Near to the free wall of the ventricle it separates into many tendinous branches shown in the figure, which would take too long a space to describe individually. These spread out in their abundant ramifications and anastomoses over a considerable area

Text-fig. 222.



A portion of the heart of *Tamandua*, with the right ventricle opened to display the moderator band (*m.*).

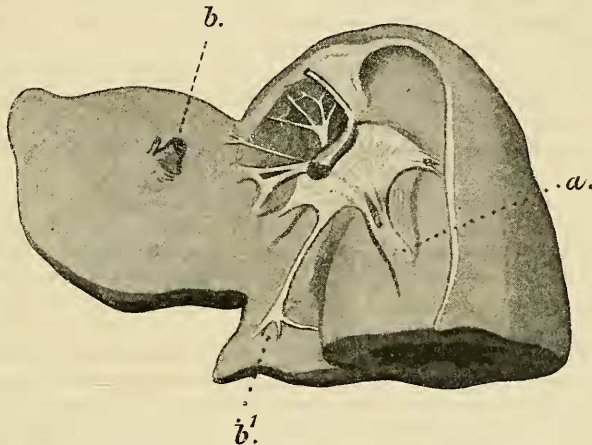
of the free wall of the ventricle. A single tendinous thread arising near to but independently of the moderator band also connects the septal with the free wall of the ventricle. Moderator bands are not uncommon* in the right ventricle, and are known in birds as well as mammals. It appears that a similarly situated moderator band occurs in the Great Anteater also. For in a figure of the interior of the right ventricle of that animal, Sir E. Ray Lankester has represented† a muscle cut off short which arises from the septal wall of the ventricle close to and behind the chief muscle of the auriculo-ventricular valve. He has not, however, given any description of this structure, with which indeed he was not concerned in the paper quoted. The right

* Cf. *e. g.* Bindo de Vecchi, *Anat. Anz.* xx, 1902, p. 374, where some literature is cited.

† P. Z. S. 1882, pl. xli. fig. 20.

auriculo-ventricular valve, which is incompletely shown in the same text-figure (text-fig. 222), has a very complicated series of papillary muscles, as is better shown in text-fig. 223. As in the Great Anteater*, the tricuspid valve is attached at the extreme left directly to the septal wall of the ventricle; there is here no development of a papillary muscle or muscles. The great or anterior papillary muscle ("a" in Sir E. Ray Lankester's figures) is partly divided into two, but not so markedly as he figures it in the genus *Myrmecophaga*. From the collar of the valve exactly opposite to the anterior papillary muscle arise two muscles which appear to be represented but are not lettered in the drawing of Lankester already referred to. These are fixed to the free wall of the ventricle. The right-hand one of them, which is the

Text-fig. 223.



The same heart with the moderator band removed to show more plainly the structure of the right auriculo-ventricular valve.

- a. The left (great) anterior papillary muscle. *b*¹. The right (lesser) papillary muscle. *b*. Muscle arising from the free wall of the ventricle and attached (the other cut end is also shown) to the actual collar of the annular valve.

smaller, is nevertheless the more conspicuous, since it is attached farther towards the apex of the heart upon the free wall of the ventricle. The arrangement of these muscles is very suggestive of the muscles lettered "m" and "n" in Lankester's figure of the heart of *Ornithorhynchus*.

The right anterior papillary muscle in *Tamandua* is a very slender muscle attached to the free wall of the ventricle. To this series may be also referred a double muscle situated more to the right, and also arising from the free wall of this ventricle.

* Cf. Lankester, *loc. cit.* fig. cit. "e."

Finally, the anterior cusp or cusps of the tricuspid valve are also attached by chordæ tendineæ to the right-hand of the two papillary muscles, which are connected with the septal cusps of the valve. It is to be noted that these muscles also spring from the free wall of the ventricle. They correspond, I take it, with those lettered "c" in Lankester's figure of the human heart. My illustration also shows the remainder of the papillary muscles of the septal flap of the valve, of which still another is attached mainly to the free wall of the ventricle. It appears to me that the chief features of interest in the structure of the right auriculo-ventricular valve of *Tamandua* are, in the first place, the very great amount of its attachment by papillary muscles to the free wall of the ventricle, in which it contrasts very markedly with such a type as *Lepus**; and, in the second place, the insertion of papillary muscles which are fleshy throughout upon the actual collar of the annular valve—a state of affairs which is closely paralleled in *Ornithorhynchus*, but is at least not always found among the Eutherian Mammals.

The *Aorta* has, at any rate, no perforate or partly perforate ductus Botalli between itself and the pulmonary artery, where they cross. I could, indeed, see no definite separate ligament representing this former arterial connection in the specimen which I dissected. On cutting open the thoracic aorta the orifices of the intercostal arteries could be counted. I examined nearly the whole of this region of the aorta; but, through an oversight, omitted to ascertain exactly the topographical limits of the section of artery which I cut open. It had been already removed from the body. In this section of aorta the first five intercostal orifices were single apertures into the aorta, though they divided at once only just below the orifice into the aorta. The sixth orifices were paired. But the two intercostal arteries opened into the aorta, one a little nearer to the heart than the other. I have already called attention to a similar asymmetry in the case of *Chiromys madagascariensis* †, where one of several pairs of intercostals opened into the aorta a little in advance of its fellow. After this pair of intercostals I counted seven single orifices into the aorta. This animal, therefore, contrasts with *Chiromys* and some other mammals, to which I have referred in the memoir quoted below, in the prevalently unpaired character of the intercostal arteries. The intercostal arteries, moreover, have a relationship to the azygos vein which varies in different mammals. It differs, for example, in *Tamandua* very much from the conditions which I have described in *Chiromys* already referred to. In *Tamandua* the right azygos vein, as in other Edentates, is the only azygos, and it extends through the whole of the thoracic cavity, down to nearly the diaphragm. It is a large vein, and gives off its branches, on the right side at least,

* Lankester, *loc. cit.* pl. xxxviii. figs. 3, 4.

† "Some Notes upon the Anatomy of *Chiromys*, &c.," P. Z. S. 1908, pp. 698 & 699, text-fig. 152.

with perfect regularity, a branch on the posterior side of each rib. There are eleven such branches behind the point where the azygos in front opens into the anterior caval to form the ductus Cuvieri. To each of these also of course corresponds an intercostal artery. Throughout the whole of its course the intercostal arteries underlie the azygos when viewed in the ordinary position of dissection. That is to say, they are dorsal to it. The azygos ends, after the last branch already mentioned, without any diminution of calibre by plunging into the thickness of the body-wall. It is only after this point that the intercostal arteries are visible throughout their whole extent from their origin from the aorta to their entering the body-wall. This state of affairs contrasts with that of, at any rate, a large number of mammals including, as already mentioned, *Chiromys*. In all mammals which I have hitherto examined as to this point, the first set of intercostals, varying in number in different mammals, underlie the azygos, and then at a fixed point, varying for the species or genus, they cross over the vein overlying it in the position in which they are seen on dissection. So that the intercostal arteries can be divided into two series, of which one set are dorsal and the other ventral to the azygos. This difference in the conditions found among mammals has no relation, as it would appear, to the length of the azygos. They sometimes cross the azygos some way from its end in cases where the vein extends quite as far back towards the diaphragm as it does in *Tamandua tetradactyla*. Posteriorly the aorta divides into two branches, each of which at once divides again to form external and internal iliacs. The caudal artery arises from the right-hand inner iliac.

Postcaval veins and their branches.—In a recent paper upon the postcaval vein in Mammals I have, I believe, quoted the authorities for the principal facts known about the main venous trunks of the Edentata. I need not, therefore, recapitulate the literature here. It is not, however, certainly known whether *Tamandua* agrees with other Edentates in the double postrenal section of the postcaval. It might well be inferred, however, that this was the case on account of its close resemblance in other characters to *Myrmecophaga*. As a matter of fact *Tamandua tetradactyla* has double postrenal postcavals, which I am now able to describe together with their principal branches. The postcaval vein is double from quite the beginning of the kidney region, as is also the case with *Myrmecophaga*. The renal veins, which are single, are given off from the divided part of the postcaval, in both of which particulars this Edentate differs from some others, for example from *Tatusia peba* *. The divided postcaval, after the origin of the renals, closely embraces the aorta which just fills up the gap.

The *spermatic veins*, as in other Edentates, arise from the

* Beddard, "On the Postcaval Vein," P. Z. S. 1909, p. 509, text-fig. 135.

renals on each side. They run straight to each testis, and the vessels appear to form a rete in the suspensory membrane of the testis in which they lie. This formation of a rete is seen in other cases among the Edentata—for example in various Armadillos, where it has been figured by Hochstetter and by myself. There is, however, in this no essential difference from what is seen in other mammals; for generally the spermatic veins in the neighbourhood of the testes or ovaries form a rete. It is only more conspicuous, and commences further away from the testes, in the Edentata now under consideration. The veins which pass between the testes and the postcaval vein seem to me to be limited to the equivalents of the anterior spermatic veins of other mammals. I could find no trace in *Tamandua* of a posterior spermatic vein joining the anterior on each side and flowing into the postcaval in the lumbar region, such as does occur in some Armadillos and in most Marsupials in addition to the anterior pair. I feel quite convinced that this is really the case in *Tamandua*, for after searching for the vein I carefully cut the suspensory ligament of each testis and observed no bleeding or the slightest trace of the smallest vessel in this ligament other than those already referred to. It will be remembered that the Armadillos vary from species to species in the presence or absence of a posterior spermatic vein.

There are no *lumbar parietal veins* given off until some way after the two postcavals have diverged greatly from each other towards the thighs in the pelvic region. Here two such veins are given off, at any rate on the right side where I studied them most carefully. The two veins anastomose just before entering the postcaval. Owing to the position of the vein where they arise, the lumbar parietals run anteriorly parallel with the long axis of the body. Each vein lies one on each side of a corresponding artery. On the opposite side of the postcaval is a corresponding pair of small veins which run in exactly the opposite direction, *i. e.* towards the pubic symphysis. Here again the two veins lie one on each side of a corresponding artery. The position of the lumbar parietal veins is quite suggestive of the lateral abdominal vein in Lizards.

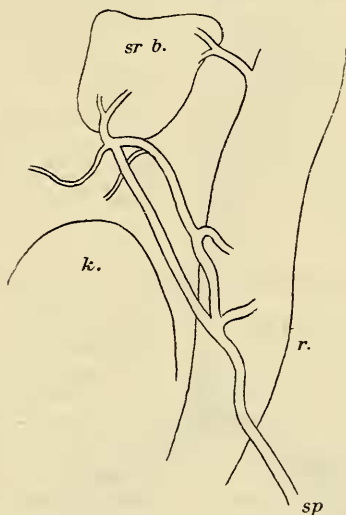
The double character of these lumbar veins is to be noted, since in other mammals, for instance among the Carnivora*, these veins are frequently double from the very first, or begin to be so at a very short distance away from their orifice into the postcaval vein or veins.

Although there is no direct affluent into the postcaval below the orifice of the renal veins of a spermatic vein on either side comparable to the posterior spermatic vein of other mammals, *Tamandua* possesses on each side of the body a peculiar longitudinal vein, which I have studied more exactly on the right side of the body; I have, however, ascertained that the vein

* Beddard, "Anatomy of *Galidia*, &c.," P. Z. S. 1909, p. 486, text-figs. 129 & 130.

exists on the left side and has substantially the same origin and course, though I can give no details so minute as I am able to give of the right-hand vein. The right suprarenal body emits a short vein which runs rather backwards and opens into the undivided section of the postcaval. The lower part of the suprarenal body behind that part which is connected with the suprarenal vein proper gives off some twigs which are connected with two or three slender veins supplying the parietes in front of the kidney. These various veins collect into a stronger vein with which their exact connections are shown in the accompanying figure (text-fig. 224). This vein is twice connected with the

Text-fig. 224.

Diagram of persistent right postcardinal (?) of *Tamandua*.

r. Right renal vein. *k.* Outline of kidney. *sr.b.* Suprarenal body. *sp.* Spermatic vein, which represents persistent cardinal and opens into renal vein &c.

postcaval by short branches and it runs close to the postcaval vein and ventrally to it, *i.e.* on top of it as seen in dissecting the animal. The vein crosses over the renal and passes into the mesorchium, joining the spermatic plexus in a way which I have not exactly ascertained. Here then is a vein which lies on the whole to the outside of the postcaval and which conveys blood from the testis, not only directly to the postcaval, but also to the suprarenal body and to the parietes in its immediate neighbourhood. There are at present no embryological data as to the veins of the Edentata. But it is to be assumed in the meantime that like other Mammals the postrenal sections of the postcavals

are to be referred to the subcardinals. And also that the postcardinals partly persist as a portion of the spermatics. If this be so, then the vein which I have just described will be referable to a more largely persisting postcardinal on each side. The orifices into the postcaval will be the remains of the frequent junctions between the postcardinal and the subcardinal. Innumerable such junctions, for instance, are figured by McClure in the embryo *Dasyure**. Moreover, a vein connecting in its course the gonad and the suprarenal bodies and the parietes is suggestive of the suprarenal parietals of the lower Vertebrata, which are perhaps to be looked upon, as I have suggested, as remnants of the postcardinals in that region. It will be noted, of course, that this longitudinally running vein cannot possibly be regarded as the missing posterior spermatic; for it opens into the postcardinals on each side in a region too anterior to permit of a comparison with that vein in other Mammals.

I did not find any caudal plexus of veins such as is to be met with in many but not in all (?) *Dasypodidæ*.

The *portal vein* on reaching the pancreas received a strong gastro-splenic branch consisting of a short vessel from the stomach and a long vein running along the whole length of the pancreas to the spleen. The main gastric branch entered nearer to its entry into the liver.

On the Postcaval Vein and its branches in Orycteropus capensis.

In completing an account of the double postcaval vein and its branches in Armadillos and in *Manis gigantea*, Dr. Hochstetter† observed that "Das Vorkommen einer doppelten hinteren Hohlvene scheint demnach bei den Gürtel- und Schuppenthieren die Regel zu sein, und es wäre nicht uninteressant, zu erfahren, wie sich in dieser Richtung die anderen Edentaten verhalten." This expectation was realised by the same writer, who later‡ described these veins in the *Bradypodidæ*. I have myself§ dealt with a few Armadillos which were not known to Hochstetter, and in the present communication to the Society with the double postcaval vein of *Tamandua*||.

I am now able to add an appendix descriptive of the postcaval vein and its branches in *Orycteropus*, which have not, as I believe, been described, unless my predecessors in this department of anatomy have overlooked some earlier account. Even in that case a redescription of veins, which are known to vary at times from individual to individual, will not be without its use.

The specimen of *Orycteropus capensis* which I dissected was a male which died on May 31st last; it was not an old individual for the testes were completely abdominal¶, lying not very far

* Am. Journ. Nat. 1906, vol. v. p. 176, fig. 9.

† Morph. Jahrb. Bd. xx. 1893, p. 622.

‡ Morph. Jahrb. Bd. xxv. 1898, p. 362.

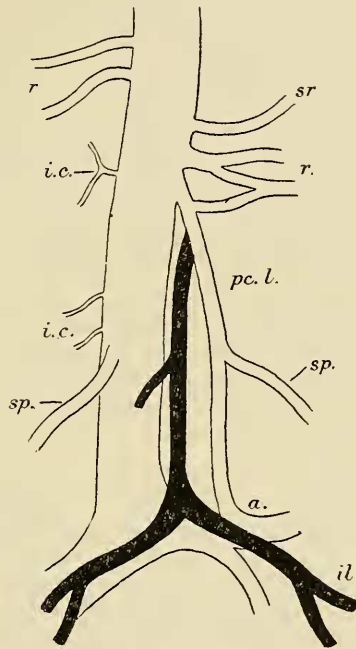
§ P. Z. S. 1909, p. 505.

|| *Suprà*, p. 699.

¶ See Flower, "On the Edentates," P. Z. S. 1882, p. 364.

behind the kidneys, whereas in the adult they are at least inguinal and even descend it is alleged into a scrotum during the breeding season. The animal measured about 4 feet 6 inches and was, therefore, obviously not full grown. On the other hand, it was as clearly in no way "newborn," and thus the long retention of the testes within the abdomen must be a character of the animal and not a mark of juvenility.

Text-fig. 225.

Postcaval veins of *Orycteropus*.

a. Point of junction of left postcaval and left iliac vein. *i.c.* Intercostal veins.
il. Iliac artery. *pc.l.* Left (smaller) postcaval. *r.* Renal veins. *sr.* Suprarenal veins. *sp.* Spermatic veins.

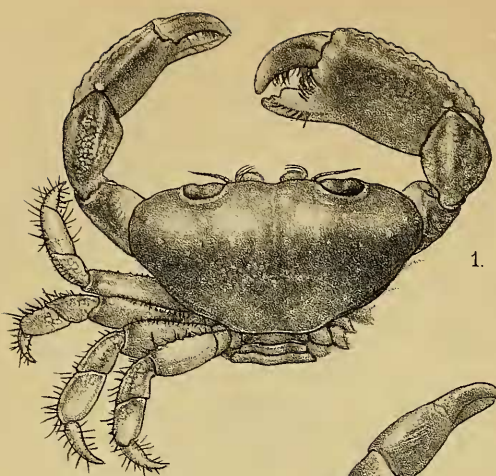
The veins were quite full of blood and in consequence easy to follow. I am able therefore to give, with some confidence, the following results of my examination of this specimen of *Orycteropus capensis*. The postcaval vein at first sight appeared to be single. For in the middle line (text-fig. 225), or nearly so, to the right of the aorta, lay a large turgid vein of the full calibre that such a vein would be expected to possess in an animal of this size. A closer examination, however, soon showed that on the opposite side of the aorta, *i. e.* on the left side, lay another vessel, parallel

to the first mentioned and not more than one third of its calibre, which was also distended with blood. I believe that so marked a difference in size between the two postcaval veins, when there are two, is not an even exceptional occurrence among Mammals. It recalls the unequal postcavals in the Lacertilian genus *Tiliqua*. In Lizards the two postcavals are apt to be equal, but among the Skinks are at least sometimes unequal in calibre. There is no question, it will be noted, in *Orycteropus* of a minute disagreement in size between the two postcavals. The difference is so great that the left-hand vein was in the first place altogether overlooked and regarded as being merely the proximal end of the spermatic vein of that side of the body. It is thus important to recognise a well-marked difference between *Orycteropus* and other Edentates at the very first. Still there remains the more important fact of the double nature of the postrenal section of the postcaval. The less important part played by the left-hand division in the venous system of this Edentate as compared with other Edentata is also shown by the posterior ending of the left postcaval and by the origin of the intercostal veins. As to the former point, it is to be noted that the large right-hand postcaval, arrived at the posterior end of the abdominal cavity, divides, as usual in animals with but a single postcaval vein, into the two iliacs. These in the usual way underlie the aorta and its posterior bifurcation, as is shown in the accompanying illustration (text-fig. 225, p. 701). When the left-hand postcava is followed backwards it is seen to open into the left iliac vein. Of this vein it is clearly a rather unimportant affluent, for the main trunk reaches the right postcava.

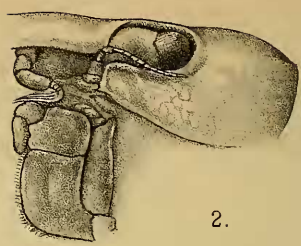
The arrangement of the two postcavæ is thus different from that of other Edentates, where the independence of the two trunks is emphasized by the fact that each is concerned with the iliac vein of its own side, or if there be a communication between them it is of such a kind as not to interfere with the equal importance of the two veins, such as, for example, the two communications which I have figured in the Insectivore *Centetes ecaudatus* *. The remaining point of difference between the two postcaval veins concerns, as has been stated, the intercostal veins. Of these there are three lying between the point of bifurcation of the veins and the right-hand spermatic vein. The intercostal veins, however, have nothing whatever to do with the left postcaval trunk. They all open into the large right postcaval and rather to the left of the vessel so that their position is very nearly, if not actually, median. They were of small size although they were full of blood, and the first of the three divided immediately after, or rather before, its entrance into the right postcaval into two branches, an anterior and a posterior. The veins, in fact, are not paired as right and left trunks.

There is thus in *Orycteropus* an approach to the more usual

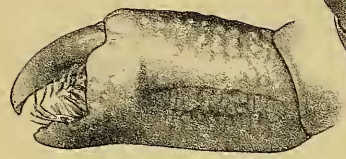
* P. Z. S. 1909, p. 511, text-fig. 136, A.



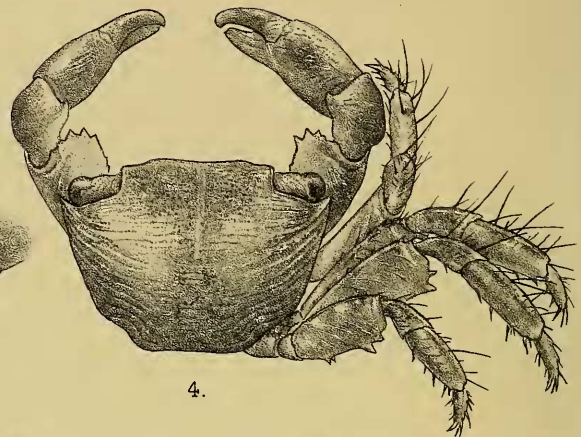
1.



2.



3.



4.



5.



7.



9.



6.



8.

G.M. Woodward del. et lith.

West, Newman imp.

1-3, LIOXANTHODES ALCOCKI. 4, 5, SESARMA MURRAYI. 6, 7, HYASTENUS ANDREWSI. 8, 9, H. UNCIFER.

Eutherian condition of the postcaval vein. Furthermore the two veins may be compared with the *Didelphys* embryo figured by McClure*, where the right cardinal collateral is immensely larger than the left-hand vein. This is one among many variations which occur in the venous system of the embryos, as well as the adults, of that marsupial. Both this variation in *Didelphys* and the adult condition in *Orycteropus* appear to me to be an intermediate step in the reduction of the two veins found in Monotremes and Edentates to the single right-hand postrenal postcaval of other Eutheria.

I now turn to the branches of the postcaval vein. The renals are as is usual asymmetrical, the right-hand veins flowing into the postcaval a little anteriorly to those of the left side. There are two renal veins on each side, and those of the left are connected by an obliquely running joining vessel. Of these two latter vessels the anterior arises from the postcaval vein, where it is single, and the posterior from the slender left postcaval. It is very important to notice, from the point of view of a comparison with other Edentates, that the renals are quite unconnected with the spermatic veins. No recognisable branch appeared accompanying the ureter. The spermatic veins themselves, as is shown in text-figure 225, are quite symmetrical with each other and arise each from its own postcaval vein about half-way down between the renal and the posterior bifurcation of the postcaval.

There is no caudal plexus and the veins are not so massive as in various Armadillos; nor is there any tendency to form plexuses, such as are often met with in the Armadillos. In fact the venous system of *Orycteropus* is in its entirety more approaching that of other Eutherian Mammals.

3. On Decapod Crustacea from Christmas Island, collected by Dr. C. W. Andrews, F.R.S., F.Z.S. By W. T. CALMAN, D.Sc., F.Z.S.†

[Received May 22, 1909.]

(Plate LXXII.‡)

I. *Introductory.*

This paper deals with the Decapoda collected by Dr. Andrews on his second visit to Christmas Island in 1908. The names of a few specimens obtained during his stay on the island in 1897-98 but not hitherto determined are also included in the list given below.

Dr. Andrews has pointed out (P. Z. S. 1900, p. 116) that "the shores of Christmas Island are singularly unfavourable for the collection of marine animals," and practically all the marine

* Am. Journ. Anat. vol. v. no. 2, 1906, p. 193, fig. 15.

† Published by permission of the Trustees of the British Museum.

‡ For explanation of the Plate see p. 713.

species here recorded were obtained in one place, at Flying-fish Cove. In addition to collections made on the reef a rich fauna was found sheltering in crevices of the wooden piles of the pier, and many of the smaller Decapoda, as well as Isopoda, Amphipoda, and Pycnogonida, were got in this way.

It would be of much interest to determine whether the littoral fauna of Christmas Island shows any peculiarities correlated with its very isolated geographical position. The present collection, at all events, gives no clear evidence of any such peculiarities; the larger Decapods, without exception, belong to well-known and widely-ranging Indo-Pacific species, while the few new species which I have to describe belong to the groups of the smaller and less conspicuous forms among which novelties may be expected anywhere. On the other hand, the restricted opportunities for collecting forbid us to attach any importance to the absence of many widely-distributed species from the collection. It must be borne in mind also that our knowledge of the Indo-Pacific littoral Decapods is still far from adequate for discussion of zoogeographical problems.

The terrestrial and fresh-water species in the following list are distinguished by an asterisk. All of these have been already recorded from the island (although sometimes under different names) except the two species of *Geograpsus* which, Dr. Andrews tells me, are abundant on the shore terrace at Flying-fish Cove. *Ptychognathus pusillus* was found only in the pool above the waterfall on the east coast, where it was collected by Dr. Hanitsch*, but *Palaemon lar* (apparently identical with the variety described by Dr. de Man, *l. c.*) was found not only in that locality but also in Hugh's Dale and Sidney's Dale on the west coast.

A few minute crabs and a larger number of small Caridea remain over which I cannot identify with any described species but which, from the imperfection of the specimens or for other reasons, I do not attempt to describe as new. The Alpheidæ, of which a number were collected on the reef, are omitted altogether for the present.

II. List of the Species.

XANTHIDÆ.

- Carpilodes rugatus* (Latr.).
 „ *vaillantianus* A. M.-E.
 „ *cariosus* Alc.
Liocanthodes alcocki, g. et sp. n.
Zozymus ieneus (Linn.).
Lophozozymus dodone (Herbst).
Xantho bidentatus A. M.-E.
Leptodius sanguineus M.-E.
 „ *cavipes* (Dana).

* See de Man, P. Z. S. 1905, p. 537.

XANTHIDÆ (continued).

- Actea tomentosa* M.-E.
 ,, *rufopunctata* M.-E.
 ,, *speciosa* (Dana).
Daira perlata (Herbst).
Xanthodes lamarckii (M.-E.).
 ,, *notatus* Dana.
Chlorodius niger (Forsk.).
 ,, *lavissimus* Dana.
Phymodius sculptus (A. M.-E.).
Chlorodopsis areolata (M.-E.).
 ,, *venusta* Rathbun (?).
Cyclodius gracilis Dana.
Cymo melanodactylus de Haan.
Eriphia levimana Latr.
 ,, *scabricula* Dana.
Trapezia cymodoce (Herbst).
 ,, *ferruginea* Latr.
 ,, *ferruginea*, var. *areolata* Dana.
 ,, *digitalis* Latr.
 ,, *rufopunctata* (Herbst).
Tetralia glaberrima (Herbst).
Domecia hispida Eydoux & Souleyet.
Melia tessellata Latr.

PORTUNIDÆ.

- Thalamita* sp. (juv.).

OCYPODIDÆ.

- Ocyroda ceratophthalma* (Pallas).

GRAPSIDÆ.

- Grapsus grapsus* (Linn.).
 ,, *strigosus* (Herbst).
 * *Geograpsus grayi* (M.-E.).
 * ,, *crinipes* (Dana).
 * *Ptychognathus pusillus* Heller.
Sesarma murayi, sp. n.
Liolophus planissimus (Herbst).

GECARCINIDÆ.

- * *Cardisoma hirtipes* Dana.
 * *Gecarcoidea lalandii* M.-E.

MAIIDÆ.

- Acheus spinosus* Miers (?).
Oncinopus aranea de Haan.
Camposcia retusa Latr.
Hyastenus andrewsi, sp. n.
 ,, *uncifer*, sp. n.
Tylocarcinus gracilis Miers.
Perinea tumida Dana.
Schizophrys aspera (M.-E.).

DYNOMENIDÆ.

Dynomene sp.

PORCELLANIDÆ.

Petrolisthes dentatus (M.-E.)." *coccineus* (Owen) (?).*Pachycheles sculptus* (A. M.-E.).

GALATHEIDÆ.

Galathea affinis Ortmann (?).

PAGURIDÆ.

Calcinus herbstii de Man.

CÆNOBITIDÆ.

* *Cænobita rugosus* M.-E.* " *clypeatus* Latr.* *Birgus latro* (Linn.).

PALINURIDÆ.

Panulirus penicillatus (Olivier)." *versicolor* (Latr.).†" *longipes* (M.-E.) (? juv.).

STENOPIDÆ.

Stenopus hispidus (Olivier).

HIPPOLYTIDÆ.

Lysmata seticaudata (Risso).

PANDALIDÆ.

Thalassocaris lucida (Dana).

PALEMONIDÆ.

* *Palemon lar* Fabr., var.*Corallicaris graminea* (Dana)." *superba* (Dana) (?).III. *Systematic Notes and Descriptions of New Species.*

Family XANTHIDÆ.

LIOXANTHODES, gen. nov.

Carapace extremely broad, strongly convex antero-posteriorly, smooth; antero-lateral borders thick, with only traces of division into three lobes; postero-lateral borders very strongly convergent, straight.

Front one-third of width of carapace, strongly deflexed, slightly notched. Orbits large, without suture-lines. Fronto-orbital border about two-thirds of width of carapace.

Antennules folded transversely. Basal antennal segment short

† I have described elsewhere some young stages of this species obtained by Dr. Andrews (Ann. Mag. Nat. Hist. (8) iii. p. 441, 1909).

and broad, not reaching front; the short flagellum standing in orbital hiatus.

Endostomial ridges very slightly developed, not reaching to anterior margin of buccal frame.

Chelipeds massive, unequal in both sexes; fingers not hollowed at tip.

Abdomen of male with third to fifth somites coalesced.

Type species, *L. alcocki*, sp. n.

The little crab described below presents a combination of characters which seems to exclude it from any of the existing genera of Xanthidæ. The great width of the carapace gives it the facies of a *Liomera*, but it differs widely from that genus and its immediate allies in the proportionate width of the fronto-orbital border, a character which would refer the species to the neighbourhood of *Xanthodes* in the sub-family Chlorodinæ of Alcock's classification. The massive chelipeds recall those of the Trapezioida, but in this character *Liomera longimana* A. M.-E. (Crust. Miss. Sci. Mexique, p. 240, pl. xlvi. fig. 1) makes some approach to the new species.

Lt.-Col. Alcock, F.R.S., to whom I have fortunately been able to submit the specimens of this crab, tells me that he considers *Liomera sodalis* Alc. (Jour. Asiatic Soc. Bengal, lxvii. (2) p. 88, 1898) to be probably congeneric with it.

LIOXANTHODES ALCOCKI, sp. n. (Plate LXXII. figs. 1-3.)

Carapace a little less than twice as broad as long, strongly convex antero-posteriorly, slightly so from side to side; surface smooth and polished, without inter-regional markings except for a shallow meso-gastric groove and a pair of crescentic depressions parallel to the inner edges of the orbits. The greatest width is well in front of the middle of the carapace and the straight postero-lateral margins are strongly convergent. The strongly arched antero-lateral margins show the faintest possible traces of three teeth or lobes, and in front of the second and third of these on the dorsal surface is a shallow pit in which are set a few hairs. The front is very much deflexed and its margin is one-third of the width of the carapace or a little less; there is a shallow median notch, and the lateral lobes are nearly straight and not separated from the inner supra-orbital angles. The orbits are very large, and the eyes, when retracted, are incompletely hidden; the fronto-orbital width is about two-thirds of the width of the carapace.

The basal antennal segment is short and broad, reaching to the inner sub-orbital angle but not to the front. It appears to touch a small downward process from the front.

The endostome has a pair of very slight ridges which do not nearly reach its front margin.

The exopod of the third maxillipeds is about half as wide as the ischium; the merus is broader than long; the ischium has a longitudinal groove.

The chelipeds are very massive and very unequal in both sexes;

a considerable part of the length of the merus projects beyond the carapace and its margins are smooth; the carpus has a blunt inner angle; in the larger cheliped the palm is slightly compressed, about three-fourths as high as long, its outer surface with longitudinal rows of low, smooth tubercles; the fingers are short, the immovable one only about one-fourth as long as the lower edge of the palm; both fingers are furrowed and toothed, with a good deal of hair on the inner edges, not excavated at the tips. The smaller cheliped is more slender, its outer surface nearly smooth.

The walking legs have the segments rather broad and flattened and beset with longish hairs, especially distally.

In the male the third, fourth, and fifth abdominal somites are coalesced.

Colour (in spirit) dark brown, marbled on the posterior part of the carapace and on the limbs with yellowish; under parts yellowish. The chelipeds have a longitudinal whitish band on the outer surface of the hand.

In the larger of two ovigerous females the carapace measures only 2.2 mm. in length by 4.2 mm. in breadth, so that the species is one of the smallest of the Brachyura. The eggs are about .35 mm. in diameter.

Family GRAPSIDÆ.

SESARMA MURRAYI, sp. n. (Plate LXXII. figs. 4, 5.)

Carapace moderately convex, much broader than long, the four post-frontal lobes not prominent, sub-equal; except for a deep transverse groove between the gastric and cardiac regions the inter-regional grooves are not defined; the whole surface is covered with sharply-marked transverse striæ, becoming oblique on the branchial regions and breaking up into rows of minute granules anteriorly. Front more than half the width of the carapace, nearly straight as seen from above. Lateral margins strongly convergent posteriorly, without teeth behind the orbital angle.

Chelipeds a little larger in the male than in the female. The anterior margin of the merus is expanded, finely serrated for the greater part of its length and cut into two or three large teeth distally. The outer surface of the merus and carpus is transversely striate, the striæ microscopically beaded. The outer surface of the hand is nearly smooth except for a fine longitudinal line near the lower border; the upper surface has a longitudinal line running along its whole length with a number of oblique lines on the inner side. In some specimens a few fainter oblique lines are also present on the outer side. All these lines, although sharply cut, are very fine and are microscopically beaded. The upper surface of the dactylus is rounded and quite smooth except for a few very fine oblique beaded lines near the base in both sexes.

The merus of the walking legs has two or three strong teeth at the distal end of its hinder edge and, in addition, the merus of the last pair has two smaller teeth side by side near the proximal end. The legs carry rather long hairs and the dactylus is strongly spined.

Measurements :—

	Male.	Female (ovigerous).
Length of carapace.....	4·5 mm.	3·75 mm.
Breadth of "	6·6 "	5·75 "
(between orbital angles)		
Breadth of front	3·75 "	3·0 "

Remarks :—Assuming that the fine beaded lines on the upper surface of the hand represent the "pectinated ridges" found in the males of some other species of *Sesarma*, this little species will fall into the third section or sub-genus (*Parasesarma*) in de Man's classification of the genus. Within this section it comes into relation with a group of species, all of small size, which are distinguished by the toothed meropodites of the walking legs. So far as I am aware only four species of this group have been described—*S. vestita* Stimpson*, *S. andersoni* de Man, *S. edamensis* de Man, and *S. batavica* Moreira (= *S. barbimana* de Man, nec Cano). In all of these the pectinated ridges on the upper surface of the hand are more strongly developed than in the new species and are differently arranged; the upper edge of the dactylus of the chelipeds is strongly "milled" in all except *S. vestita*, where it is stated to be acute; and none of the species possesses teeth at the proximal end of the merus of the last pair of legs. Further, *S. batavica* is distinguished by the tufts of hair on the fingers, *S. edamensis* by the much broader legs, *S. andersoni* by having the carapace smooth and the sides much less strongly convergent posteriorly, and *S. vestita* by having the carapace only a little longer than broad (breadth-ratio 1·03 as against 1·46 to 1·53 in the new species). Outside of de Man's third section, the only species of *Sesarma* which are described as having the meropodites of the legs toothed are *S. minuta* de Man and *S. barbimana* Cano, both of which are separated from the species here described by the presence on the lateral margin of a tooth behind the orbital angle.

The specimens of this crab were collected on the shore at Flying-fish Cove.

The specific name is chosen in compliment to Sir John Murray, K.C.B., F.R.S., by whom the specimens described in this paper have been presented to the British Museum.

* This is referred by de Man to his first section (Zool. Jahrb. ii. p. 644, 1887), but the recently published description and figure (Stimpson's Rep. Crust. N. Pacific Expl. Exp., Smithsonian Miscell. Coll. xlix. p. 136, pl. xiii. fig. 6, 1907) show that the species possesses pectinated ridges on the upper surface of the hand and must be referred to de Man's third section.

Family GECARCINIDÆ.

GECARCOIDEA LALANDII Milne-Edwards.

G. lalandii Ortmann, Zool. Jahrb., Abth. Syst. vii. p. 738 (1893).

To the synonymy given by Ortmann the following are to be added:—

Hylæocarcinus natalis Pocock, P. Z. S., 1888, p. 561.

Pelocarcinus humei (Wood-Mason) Alcock, Jour. Asiatic Soc. Bengal, lxi. pt. 2, p. 449 (1900).

Gecarcinus lagostomus (in error) Andrews, Monogr. Christmas Island, p. 163 (1900).

An examination of the Museum collection of Gecarcinidæ gives no reasons for dissenting from the synonymy which Ortmann has established for this species. The specimen recorded under this name from "S. America" by Adam White in the "List of Crustacea in the British Museum," p. 32 (1847), cannot now be traced, but a Museum copy of the List contains a note in the handwriting of Mr. Miers, "Certainly not this species," so that no confirmation is afforded of Milne-Edwards's statement that the type of the species came from Brazil.

With reference to the erroneous determination of the specimens recorded in the 'Monograph of Christmas Island' (a determination for which Dr. Andrews was not responsible) it is desirable to point out that there is no trustworthy evidence for the occurrence of *Gecarcinus lagostoma* outside the Atlantic area. Milne-Edwards indeed originally described that species as "rapporté de l'Australasie par MM. Quoy et Gaimard" (Hist. Nat. Crust. ii. p. 27, 1837), and Miers refers to a series in the British Museum obtained in the same region during the voyage of the 'Erebus' and 'Terror' (Challenger Rep. Brachyura, p. 219 footnote, 1886). With regard to the latter I can obtain no confirmation of the locality from the Museum registers. The specimens date from a time when the records of locality were less strictly kept than they are now, and it seems possible that specimens arriving at the Museum without indication of locality may have been assumed to come from the same region as the type-specimens. Miers also mentions a specimen from the Cape of Good Hope, and I may add that there is another in the collection labelled "Madagascar" but in neither case can the history of the specimens be traced.

Dr. Andrews has described (*l. c.*) the annual migration of *G. lalandii* to the sea during the rainy season for the purpose of hatching off the eggs. On his visit to the island in 1908, he obtained specimens of a large *Megalopa*-larva which occurred in enormous quantities in the sea shortly after the migration, and also of a small crab which appeared in similar numbers at a slightly later date. It seems practically certain that these larvæ and young can belong to no other species than *G. lalandii*, and it

is hoped that it may be possible to obtain the earlier stages and to give a complete account of the life-history.

CARDISOMA HIRTIPES Dana.

Cardiosoma hirtipes Alcock, Jour. Asiatic Soc. Bengal, lxi. pt. 2, p. 447 (1900).

Cardisoma carnifex (Herbst) Andrews, Monogr. Christmas Island, p. 164 (1900).

Miss Rathbun has recently employed for this species the name *C. rotundum* Quoy & Gaimard (Bull. U. S. Fish Comm. for 1903, pt. iii. p. 838, 1906), but, so far as I know, she has not explained in detail her reasons for doing so. The figure to which she refers (Freycinet's Voyage autour du Monde, Atlas Zool. pl. 77. fig. 1, 1825) is very poor, and there seems no obvious reason for taking it to represent this species rather than *C. carnifex*.

The account which Dr. Andrews has given (*l. c.*) of the habitat of this species—in deep burrows by the side of freshwater streams—agrees with what Ortmann has recorded (Zool. Jahrb., Abth. Syst. x. p. 339, 1897) of the closely allied *C. carnifex* in East Africa. Dr. Andrews tells me that he never saw this species at or near the sea (in marked contrast to *Gecarcoidea*), which also coincides with Ortmann's experience. Since nothing appears to be recorded of the breeding habits of the species of this genus, it may be worth while to mention that in the West African *C. armatum* (the only species of which the Museum possesses an ovigerous female) I find the young within the minute eggs to be in the zoea stage. There can be little doubt therefore that in this genus also the young stages are passed in the sea.

Family MAIIDÆ.

HYASTENUS ANDREWSI, sp. n. (Plate LXXII. figs. 6, 7.)

Carapace and limbs closely covered with long, thick, soft hairs which, on the walking legs and especially on the merus and carpus of the first two pairs, fringe the anterior and posterior margins and make the limb appear broad and flat. The carapace is triangular, with a convex posterior margin and, when denuded of hair, is smooth and polished, with a single low tubercle on each side of the gastric region. The gastric, cardiac, and intestinal regions are strongly convex, defined by well-marked grooves. The rostral spines are less than a quarter of the total length, coalesced for some distance in front of the orbits, deflexed at the base and curving upwards at the tip. The supra-orbital margin is not very prominent and its anterior corner is rounded off. The basal segment of the antenna is little expanded so that the floor of the orbit is very incomplete, and is without tubercle or spine at its anterior end; the free segments of the antenna are visible at the side of the rostrum and are beset with long hairs. The first

pair of walking legs are a little longer than the carapace and rostrum. The dactyli are slender, curved, and very sharp-pointed, with two or three teeth near the base on the lower edge.

An ovigerous female specimen measures 12 mm. in length to base of rostral spines, by 9 mm. across the widest part of the carapace.

Remarks:—This little crab, which I have failed to identify with any described species, differs from the usual type of *Hyastenus* by the comparatively slight development of the supra-orbital margin. In this character and in the narrowness of the basal antennal segment it seems to approach the American genus *Pelia*, from which, however, it differs in the absence of a tooth at the distal end of the same segment. As there are considerable differences in the relative development of these parts in the various species of *Hyastenus*, the new species may provisionally be placed in that genus.

HYASTENUS UNCIFER, sp. n. (Plate LXXII. figs. 8, 9.)

Carapace sub-pyriform, pointed behind, tomentose, tuberculate. There is a transverse row of five tubercles (the outer pair the largest) on the gastric region and, behind this, a single median tubercle; the cardiac region is convex and the intestinal region bears two tubercles, the posterior one acute and recurved; there is a very prominent hepatic spine, and the branchial regions bear each several tubercles and a procurved epibranchial spine. The rostral horns are equal to, or a very little shorter than the carapace (in the male), slender, divergent, and gently decurved. The supra-ocular eave is acutely produced anteriorly; there is no intermediate tooth between it and the post-ocular process, which is not expanded distally. The basal antennal segment has a sharp spine at the antero-external angle.

The chelipeds (in the female) are slender, with two or three spines on the carpus; the fingers are less than half the length of the palm and meet for the greater part of their length.

The walking legs are slender, with a few granules on the carpus, and with the dactylus armed with a row of stout recurved spines.

A female specimen measures 11 mm. in length to the base of the rostral spines.

Remarks:—In the length of the rostral horns this species approaches *H. brockii* de Man, but has the carapace more tuberculate and more pointed behind. The very prominent hepatic spine and the strong hooked teeth on the dactyli of the walking legs are unlike those of any species with which I have been able to compare it.

TYLOCARCINUS GRACILIS Miers.

T. gracilis Miers, Ann. Mag. Nat. Hist. (5) iv. p. 15 (1879).

In describing this species, Miers suggested that it might "perhaps prove to be only a variety" of *T. styx* (Herbst). The numerous specimens collected by Dr. Andrews, however, show no

perceptible approximation to *T. styx* as compared with Miers's type specimens. The long, straight, rostral spines, divergent from the base, and the more numerous and longer spines on the legs, are characters which seem to justify the separation of the species. I do not find, however, that the carapace is "much narrower" than in *T. styx*, and the rostral spines are not always more than half the length of the carapace. Dr. Andrews's collection includes some males in the breeding phase, with enlarged chelæ and widely gaping fingers.

PERINEA TUMIDA Dana.

Perinea tumida Dana, Crust. U.S. Expl. Exp. i. p. 114, pl. iv. figs. 1 *a-f* (1855); Rathbun, Bull. U.S. Fish Comm. for 1903, pt. iii. p. 881 (1906).

Parathoë rotundata Miers, Ann. Mag. Nat. Hist. (5) iv. p. 16, pl. v. figs. 2, 2 *a* (1879); Haswell, Cat. Austral. Crust. p. 30 (1882); Klunzinger, Spitz- und Spitzmundkrabben des Roten Meeres, p. 45, pl. i. figs. 7 *a-d*, text-fig. 10 (1906).

About 18 specimens of a little crab collected by Dr. Andrews are identical with the types of Miers's *Parathoë rotundata* from Port Curtis and Fiji. The rostral teeth, although short, are much more prominent than in Miers's figures and are separated by a rounded notch, and there is a small tooth at the distal end of the basal segment of the antenna unnoticed by Miers.

There can be little doubt, however, that Miers's genus and species are synonymous with those of Dana, quoted above. By the courtesy of Miss Rathbun I have been able to examine a specimen from Laysan recorded by her (*l. c.*) as *Perinea tumida* Dana. It is a large male in which, as in the large female from the Gulf of Suez mentioned by Miers, the tubercles on the carapace are rather less prominent than in smaller specimens, but it undoubtedly belongs to the same species. In addition to the differences from Dana's account mentioned by Miss Rathbun, it is to be noted that the rostral teeth are much less prominent than in the original figures and the notch between them is rounded instead of angular. The tooth at the end of the basal segment of the antennules is also less prominent. I see no reason, however, to dispute Miss Rathbun's identification of the Laysan specimen with Dana's species and if this be accepted the name given by Miers must be placed as a synonym.

EXPLANATION OF PLATE LXXII.

- Fig. 1. *Lioxanthodes alcocki*, g. et sp. n. Female, dorsal view. $\times 9$.
 2. " " " Anterior part of body, ventral view. $\times 18$.
 3. " " " Larger chela of male, from outer side.
 4. *Sesarma murrayi*, sp. n. Male, dorsal view. $\times 6$.
 5. " " " Upper surface of chela.
 6. *Hyastenus andrewsi*, sp. n. Male, dorsal view. $\times 3$.
 7. " " " Orbital region from below.
 8. *Hyastenus uncifer*, sp. n. Female, dorsal view. $\times 3$.
 9. " " " Dactylus of leg of last pair.

4. An Abnormal Individual of the Echinoid *Amblypneustes*.
By H. L. HAWKINS, B.Sc., Mark Stirrup Scholar in
the University of Manchester*.

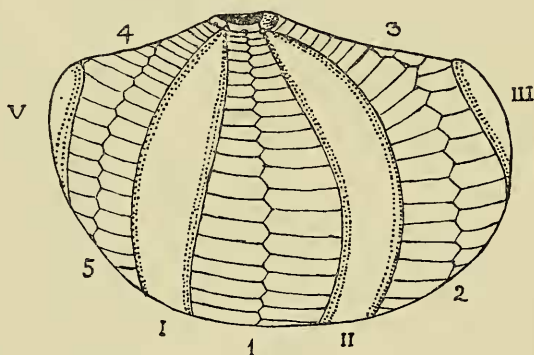
[Received June 2nd, 1909.]

(Text-figures 226-230.)

A series of the recent Echinoid *Amblypneustes* from Australian waters, preserved in the Manchester Museum, includes an individual, apparently of *A. ovum*, with a particularly fundamental abnormality, which seems worthy of brief description.

Abnormalities in the symmetry of species of *Amblypneustes* were described in 1880 by F. J. Bell and C. Stewart in the *Journal of the Linnæan Society* (vol. xv. pp. 126 & 130, pl. v.), and it would appear that the genus is one the members of which are especially liable to irregularities of development. The structural peculiarities of my specimen, however, are of a type distinct from those described in the papers referred to, and resemble those in the *Echinus esculentus* figured by Messrs. J. Ritchie and D. C. McIntosh in the *Proceedings of the Zoological Society* for 1908 (p. 646, pl. xxxiii.).

Text-fig. 226.



Lateral view of test of an abnormal *Amblypneustes*.

The outward form of the specimen is strikingly irregular. Instead of the regular ovoid shape of other specimens of the species, it is much elongated along a line almost corresponding with the antero-posterior axis. The lateral view (text-fig. 226) shows the test to be abruptly truncated apically, while the apical system of plates rises boldly above the partly concave slopes of the corona.

The adapical view (text-fig. 227) shows the remarkable feature that only three ambulacral areas reach the apical system, the two

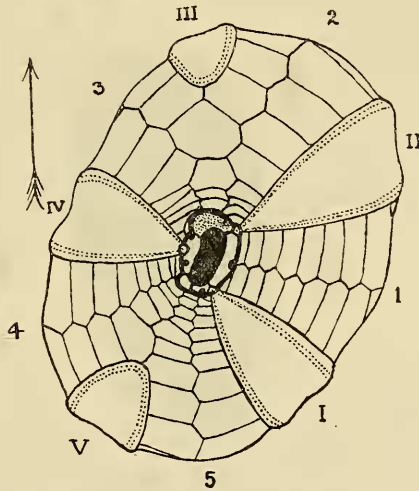
* Communicated by F. A. BATHER, F.R.S.

others, the anterior and left-posterior, being rounded off a little above the ambitus. The apical system is elongated in two directions as though to meet the defaulting ambulacra, but in each case a considerable length of non-poriferous plates intervenes between the adapical extremities of the two ambulacra and the plates from which they should spring.

The other three ambulacra show no departure from the normal type, except that the left-anterior (IV) is sensibly wider than either of the others, and less convex in longitudinal outline.

The right posterior interambulacrum (1) is the only one of normal character throughout, the other four being more or less modified adapically to counteract the absence of the ambulacra. The adoral region of the test is perfectly normal, and the peristomial aperture regularly decagonal.

Text-fig. 227.

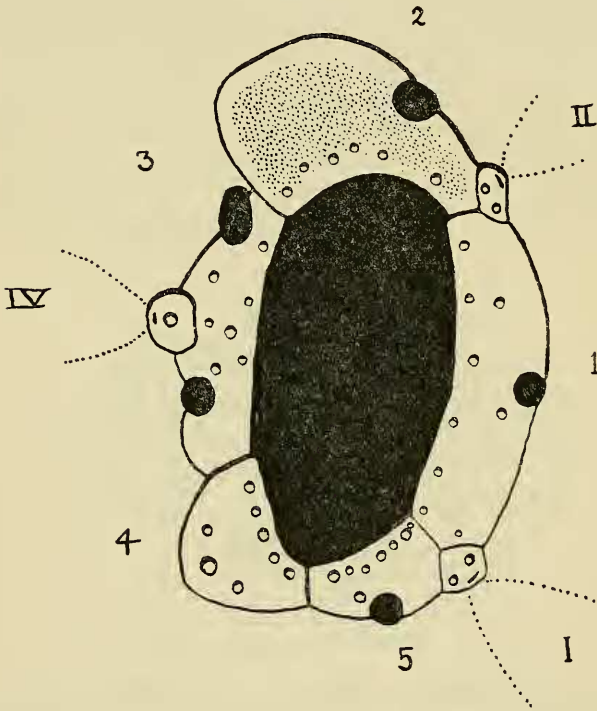
Adapical view of test of an abnormal *Amblypneustes*.

The apical system (text-fig. 228, p. 716), besides the lengthening already referred to, shows marked departures from the normal type. There are five genital plates, the inner margins of which enclose the elongated periproct, but they are of very unequal dimensions. The madreporite is large, and perforated on the right side by a small genital pore. The two adjoining genital plates on the right and left sides are elongated and depressed. The plate on the right is normally perforate, but that on the left bears two large gonopores, one near each end. The two posterior genital plates are short and convex, and closely applied to each other, forming an elevation that matches the anterior prominence of the madreporite. The right posterior plate is perforated in the usual way,

but its fellow on the left is imperforate. There are thus five genital pores distributed over four of the genital plates.

There are three ocular plates, corresponding with the termination of the three complete ambulacra; each is perforated by a minute pore. The ocular on the left is almost spherical in shape, since it abuts against the middle of the large genital (3), and not, as usual, against the two genitals (4 and 5). There is no trace of the other two ocular plates. The periproct is covered by numerous irregular plates of small size.

Text-fig. 228.

Apical system of an abnormal *Amblypneustes*.

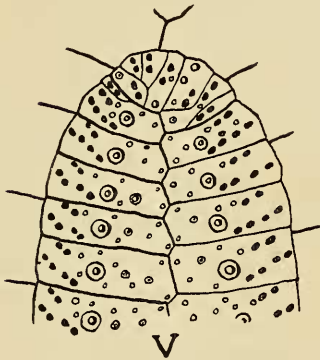
The composition of the interambulacral areas (text-fig. 227, p. 715) differs in the two affected portions of the test. The two interambulacra 4 and 5 meet above the truncated end of ambulacrum V, and, except that the suture between the two areas is somewhat irregular, continue side by side up to the apical system as a compound area of four columns of plates.

The adaptation of interambulacra 2 and 3 to the changed conditions is different. Here column *b* of area 2, and column *a*

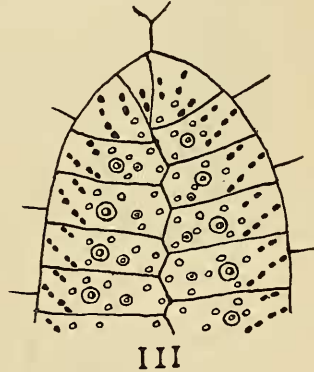
of area 3 are discontinued after they have wrapped round the adapical end of ambulacrum III, and their place is taken by a single median series of heptagonal and hexagonal plates, so that a compound area of three columns of plates abuts on the hypertrophied madreporite.

The structure of the ambulacra at and towards the ends of the truncated areas is shown in text-figures 229 and 230. The poriferous plates are seen to curve round the extremities of the zones with considerable regularity, leaving a regularly rounded outline rather than an abrupt break in the course of the growth of the area.

Text-fig. 229.



Text-fig. 230.

Abnormal ambulacra of *Amblypneustes*.

Counting from the peristome there are about 25 sets of plates in ambulacrum III, and about 28 in V. In a normal ambulacrum there are about 56.

The abnormal development, or rather, lack of development, in this specimen is quite similar to that noted by Messrs. Ritchie and McIntosh in *Echinus esculentus*, except that the retardation of ambulacral growth has affected two areas instead of one only. The development of fresh ambulacral plates seems to have been checked at a different period in the life of the animal in the case of each ambulacrum, and no such corresponding irregularities at about the same region of the other areas are to be found in the *Amblypneustes* as there were in the case of the *Echinus*. Thus the hypothesis of a uniform and temporary wound or disease affecting the growth of new plates round the apical system, which could account for the latter's abnormalities, does not seem tenable in this case. Moreover, the great irregularity in the numbers and proportions of the plates of the apical system seem to point to a more radical morbidity than is compatible with the idea of mere local injury.

It seems probable that the two missing ocular plates of the

apical system may have been resorbed, as they should have existed at the adapical extremities of the truncated ambulacra in the early and normal phase of the animal's existence. There is no sign of their having been carried down to remain in their terminal position at the ends of the ambulacra.

There is a small hole in the middle of interambulacrum 2 which does not look like a mere chance puncture inflicted after the death of the animal, as it seems to have been partly healed up by a fresh deposition of calcite from within. The hole may be the result of the activity of some boring parasite, but whether such an agent could cause the remarkable irregularities that exist in the test seems very doubtful.

The following are a few important measurements of the test:—

	mm.
Length (ant. rad. to post. interr.)	36
Breadth (at right angles to above)	31
Height (including apical system).	30
Ambitus	115
Diameter of peristome	10
Length of apical system	7·75
Breadth of apical system	5
From rad. III to nearest point of apical system .	14·5
" " V " " " " " " "	10

5. The Decapods of the Genus *Gennadas* collected by
H.M.S. 'Challenger.' By STANLEY KEMP, B.A.*

[Received June 7, 1909.]

(Plates LXXIII.—LXXV.†)

In 1881 ‡, Spence Bate established the genus *Gennadas* for the reception of certain abyssal Penæidæ found by the 'Challenger' Expedition. He recognized two species, *G. parvus* and *G. intermedius*, but his descriptions and figures, viewed from the standpoint of our present knowledge, are hopelessly inadequate. Since 1888, when the full Report on the 'Challenger' Crustacea Macrura appeared, several authors have recorded *Gennadas parvus*, but owing to the imperfections in the original description it may be doubted whether much reliance can be placed on their determinations.

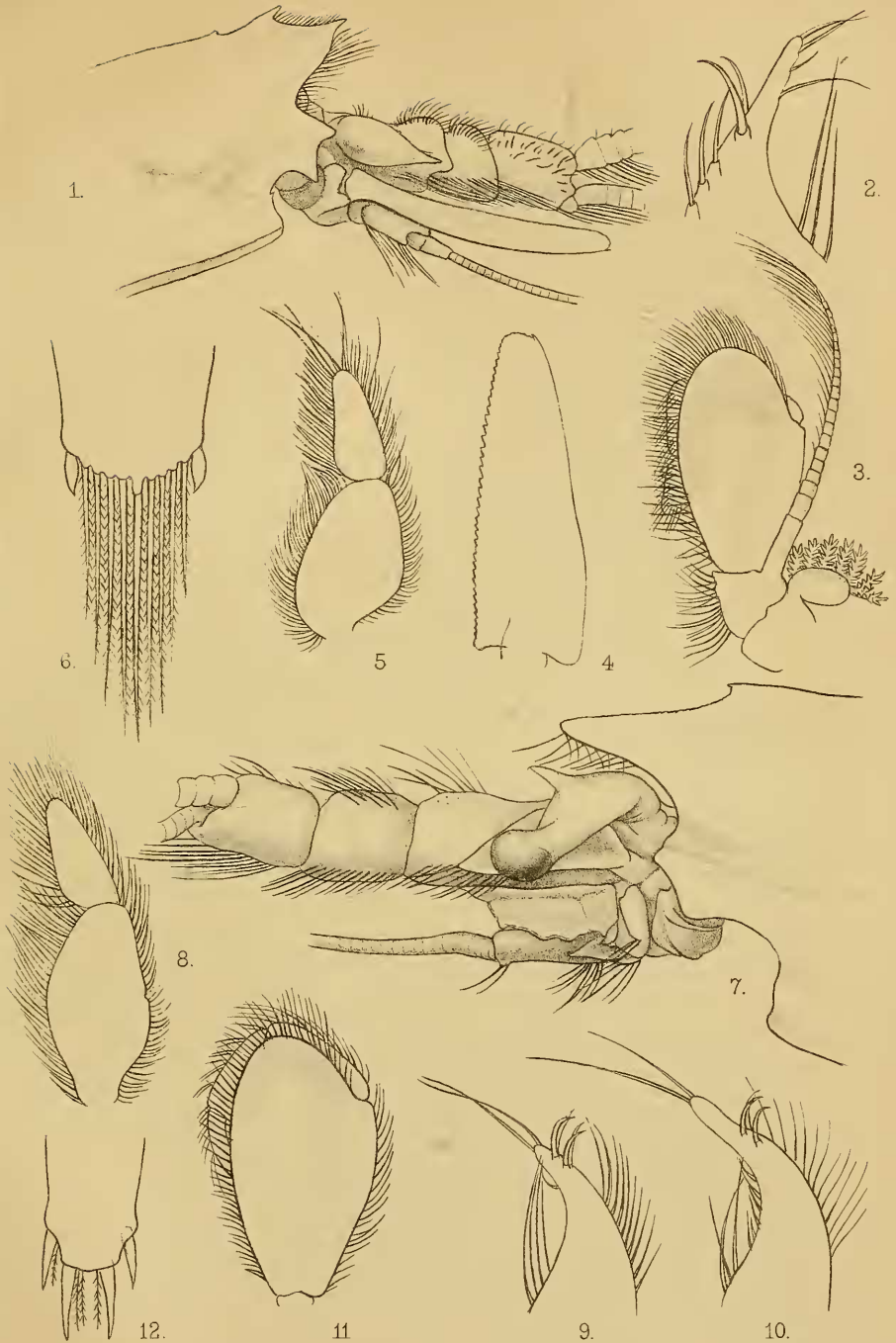
Only quite recently has any good basis been formed for future work. Bouvier, in 1906 §, outlined a scheme for the identification of six Atlantic species and emphasized the value of several characters as specific determinants; by means of these species he

* Communicated by Dr. W. T. CALMAN, F.Z.S.

† For explanation of the Plates see pp. 729 & 730.

‡ Ann. Mag. Nat. Hist. Sept. 1881, p. 91.

§ Bull. Mus. Océanog. Monaco, 80, 1906.

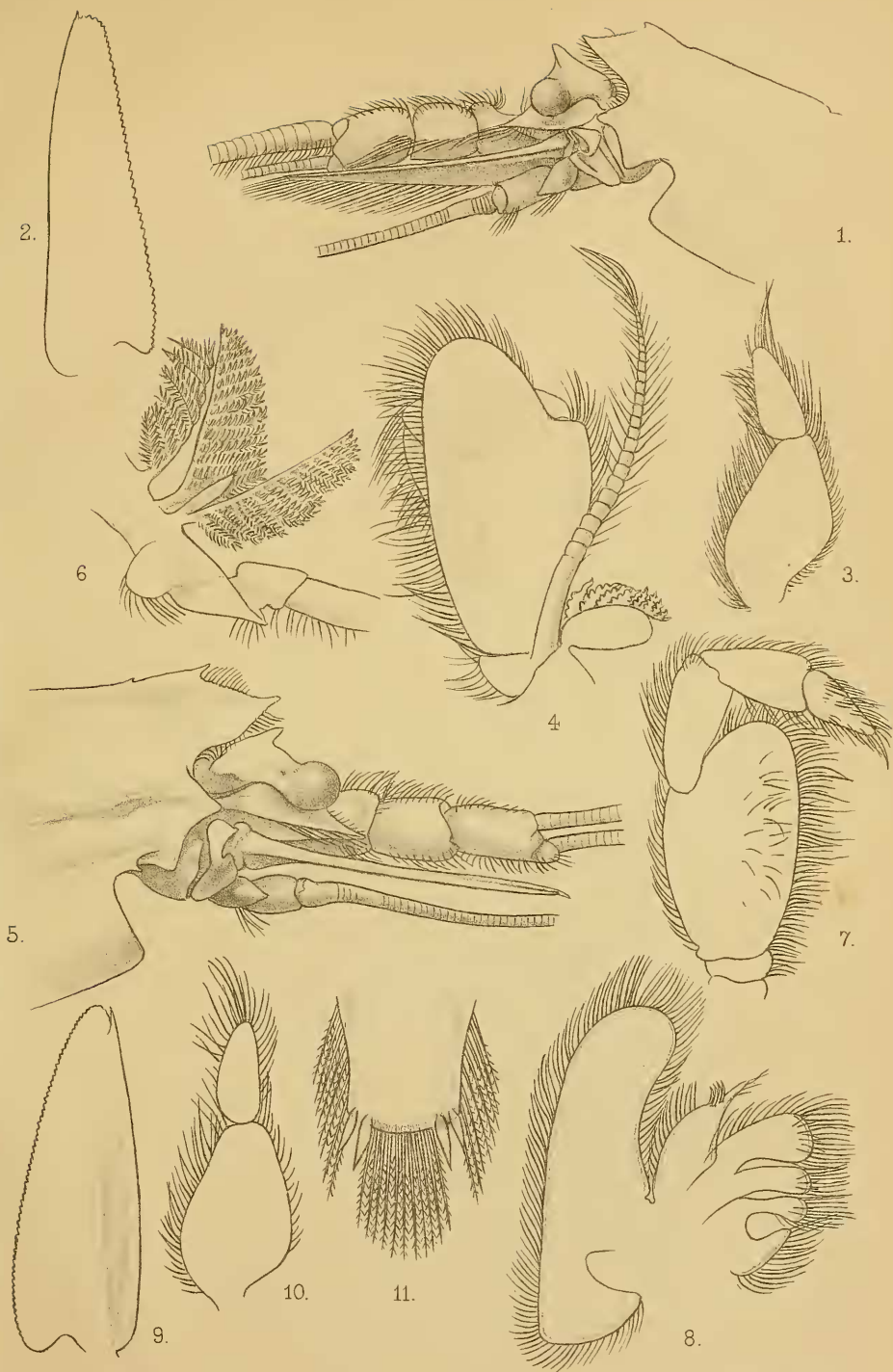


G. M. Woodward del. et lith.

West, Newman imp.

1-6. GENNADAS PARVUS.
7-12. GENNADAS INTERMEDIUS.

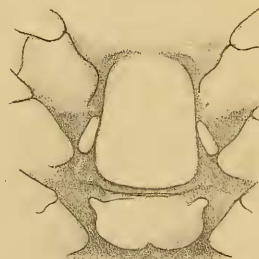
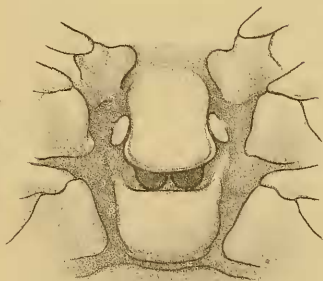
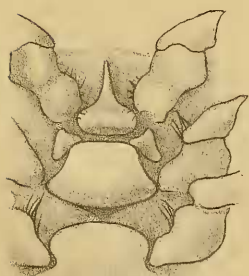
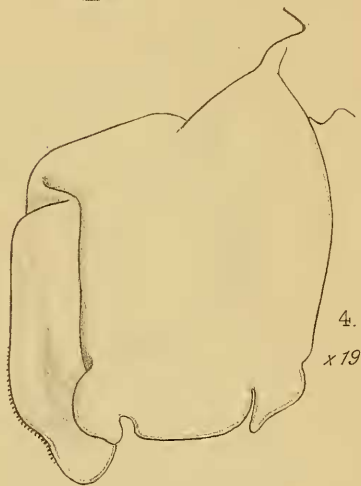
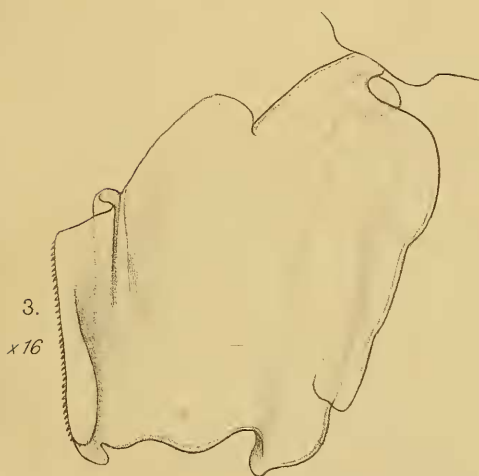
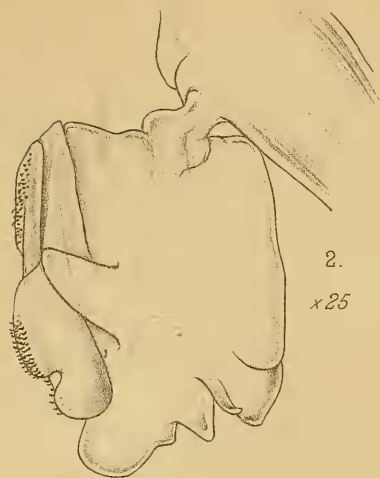




G.M.Woodward del. et lith.

West, Newman imp.

1-4. GENNADAS BOUVIERI.
5-11. GENNADAS CALMANI.



5. x7¹/₂

6.

7.

x20

G. M. Woodward del. et lith.

West, Newman imp.

1. GENNADAS PARVUS. 3. GENNADAS INTERMEDIUS.
 2. GENNADAS SCUTATUS 4-5 GENNADAS CALMANI.
 6-7 GENNADAS BOUVIERI.

was able to trace the derivation of the genus from the more primitive *Benthesicymus*. This short paper was followed in 1908* by a lavishly illustrated memoir on the Penæidæ collected by the Prince of Monaco, containing fuller treatment of the same species in addition to valuable information on other genera. These two papers have greatly facilitated any further work on the subject and the revision of the 'Challenger' material has in consequence been robbed of much of its difficulty.

Before going further it is, however, necessary to refer to the generic status of the species belonging to this group. In 1882 † S. I. Smith described, under the name of *Amalopenæus*, a genus which differs from Spence Bate's *Gennadas* only in the total suppression of the podobranchs on the first three pairs of pereopods. For some time it was thought that Spence Bate's determination of the branchial formula was incorrect—a not unreasonable hypothesis; Alcock, however, stated in 1901 that these gills were present in certain specimens of *Gennadas* from Indian waters, and an examination of the type species in the British Museum establishes the correctness of Spence Bate's observation.

On the other hand, specimens of *Amalopenæus elegans* from the N.E. coast of America show no trace of these gills, thus confirming Smith's determination and that of several subsequent writers.

The question now arises whether the presence or absence of these gills is of itself a factor of sufficient importance to justify the retention of two distinct genera—for it is almost certain that no other characters are available for their separation. Although the literature of the subject contains numerous references to this question, Bouvier, strangely enough, makes no mention of it ‡ in his memoir on the material collected by the 'Princesse-Alice.'

The nomenclature of the species is perhaps a matter of minor importance, if the relationships of the various forms are fully understood. Podobranchs are rarely found on the thoracic limbs of Decapoda Natantia; they are most frequently present in the Penæidea, and in such a tribe, which abounds in primitive characters, the absence of these gills is rightly regarded as a feature of great importance, for it indicates in no uncertain way the degree of specialization to which the species has attained §. I have consequently retained *Amalopenæus* as a distinct genus and consider Bouvier's group, *Benthesicymæ*, to comprise three

* Rés. Camp. Sci. Monaco, xxxiii. 1908.

† Bull. Mus. Comp. Zool., Harvard, vol. x. 1882.

‡ Bouvier (*loc. cit.*, 1908) regards *Amalopenæus* as a synonym of *Gennadas* and, in reference to the gill formula, merely states that it is the same as that of *Benthesicymus*. This is certainly inaccurate for at least one of the species he was dealing with, viz. *Amalopenæus (Gennadas) elegans*.

§ Although the determination of the complete gill formula in these species is a matter of some difficulty, the presence or absence of podobranchs on the first three pereopods can be observed with the greatest ease. The podobranch in *Gennadas* (Pl. LXXIV. fig. 6) is an outgrowth from the base of the epipod; in *Amalopenæus* a considerable space intervenes between the epipod and the lowest gill (an arthrobranch).

genera, *Benthesicymus*, *Gennadas*, and *Amalopenæus*, the first being the most primitive and the last the most highly specialized.

The species of *Gennadas* and *Amalopenæus* are by no means easy of determination. The best characters are undoubtedly those afforded by the membranous expansion of the endopods of the first pleopods of the male (known as the *petasma*) and by the sternal plates of the cephalothorax (the *thelycum*) in the female.

These characters are of course of little value in very young specimens, but they appear to afford trustworthy indications in all examples upwards of one half the maximum length of the species.

So far as at present known there is extremely little variation in the form of the adult *petasma*, but this is not necessarily the case with the *thelycum*, for Bouvier (1908, *loc. cit.*) has instanced several variations in the case of *Amalopenæus valens*, Smith. Although it might be expected that seasonal variations depending on the degree of sexual maturity of the individual would be manifest in both *thelycum* and *petasma*, it must be noticed that there is no evidence of this in the case of *Amalopenæus elegans*, a species of wide Atlantic distribution and of common occurrence.

Bouvier has indicated other characters of great value in the determination of the different species. Of these, the most important are the form of the antennary and infra-antennary angles, the proportional length of the second and third joints of the antennular peduncle, the proportional lengths of the ultimate joint of the mandibular palp and of the merus, carpus, and chela of the first three pairs of pereiopods. Valuable information is also afforded by the form of the antennal scale and by the presence or absence of a stout median spine on the first abdominal sternum.

The specimens referred by Spence Bate to *Gennadas parvus* and *G. intermedius* are for the most part fairly perfect; the majority of those recorded in the 'Challenger' Report are preserved in the British Museum, and the types of both species are extant. The specimens missing are four in number, viz. :—

St. 137. 35° 59' S., 1° 34' E. Recorded as *G. intermedius*.

St. 159. S. of Australia. } Recorded as *G. parvus*.

St. 250. N. Pacific. }

St. 289. S. Pacific. }

The result of an investigation of the remaining specimens, seventeen in number, is indicated in the table on p. 721.

If these results be accepted, it will be seen that Spence Bate was quite as unfortunate in his treatment of this genus as Hansen has shown him to have been with *Sergestes*.

In the following systematic notes no attempt has been made to correct the many inaccuracies which disfigure Spence Bate's work. The condensed descriptions and figures will, it is hoped, prove sufficient for the recognition of the type species and the two forms described as new. The various shapes assumed by the lobes and folds

Spence Bate's identification.	Station.	Locality.	Sex.	Author's identification.
<i>Gennadas parvus</i>	45	M. of Delaware R.	♂	<i>Amalopenæus elegans</i> , Smith. Not determined.
	101	Off Sierra Leone.		
	120	Off Pernambuco.		<i>Gennadas intermedius</i> , Sp. Bate.
	206	Off Manila.		
	220	N. of New Guinea.		<i>Gennadas bouvieri</i> , n. sp.
	do.	do.		
	do.	do.		Not determined. TYPE.
	230	S. of Japan.		
	232	do.		<i>Gennadas calmani</i> , n. sp.
	do.	do.		
do.	do.			
do.	do.			
235	do.			
<i>Gennadas intermedius</i> }	237	Off Yokohama.	♂	<i>Gennadas scutatus</i> , Bouvier. TYPE.
	267	N. Pacific.		
	106	Off Sierra Leone.		
	?	Off Bermuda.		Not determined.

of the petasma are so complicated that they almost defy adequate textual treatment; the necessary information is consequently conveyed solely by the figures.

All that is at present known of the habits of *Gennadas* and *Amalopenæus* goes to prove that they are free-swimming forms which never live on the ocean bottom. It is probable that all the specimens found by the 'Challenger' were caught during the ascent of the net; the depths given can therefore be accepted only as indications of the soundings at the different stations.

GENNADAS PARVUS Spence Bate. (Plate LXXIII. figs. 1-6; Plate LXXV. fig. 1.)

Gennadas parvus, Sp. Bate, Ann. Mag. Nat. Hist. Sept. 1881, p. 192, and 'Challenger' Crustacea Macrura, 1888, p. 340, pl. lix.

? *Gennadas parvus*, Wood-Mason, Ann. Mag. Nat. Hist. Feb. 1891, p. 189, and Oct. 1891, p. 286.

? *Gennadas parvus*, Alcock, Desc. Cat. Indian Deep Sea Macrura, 1901, p. 46.

? *Gennadas parvus*, Rathbun, U.S. Fish Comm. Bull. for 1903 (publ. 1906), p. 907, fig. 60.

St. 230. S. of Japan. 26° 29' N., 137° 57' E. Trawl. 2425 fathoms. One male, the type specimen, 25 mm.*

The rostral crest (Pl. LXXIII. fig. 1) is elevated above the dorsal carina of the carapace; its frontal margin is rather strongly convex. It bears the usual fringe of setæ between the apex and the dorsal spine, while behind the latter there is a small tubercle situated on the dorsal carina of the carapace. Both the antennary

* Measured from the apex of the rostrum to the tip of the telson.

and infra-antennary angles are strongly acute and a very small branchiostegal spine is present. The distance between the cervical and post-cervical grooves, measured dorsally, is about one-third the distance from the post-cervical groove to the hinder edge of the carapace. The mid-dorsal carina is not evident behind the latter groove.

The eyes are in very poor condition, one missing and the other badly damaged. The second joint of the antennular peduncle is very short; measured dorsally it is less than half the length of the ultimate segment. The antennal scale (Pl. LXXIII. fig. 4) is three times as long as broad and not much narrowed apically; the convex outer margin terminates in a minute spine, which hardly extends as far forward as the lamella.

The ultimate joint of the mandibular palp (Pl. LXXIII. fig. 5) is fully as long as the width of the first joint. In the second maxilla the anterior lobe of the internal lacinia is not constricted behind its apex and is not narrower than the adjacent lobe of the external lacinia. In the latter lacinia the anterior lobe is about one and a half times the width of the posterior. The endopod (Pl. LXXIII. fig. 2) is furnished with two stout curved spines behind the apex, beyond which the narrow distal prolongation bears four setæ on the inner margin. The endopod of the first maxillipede reaches slightly beyond the exopod. The third segment is one and a quarter times the length of the second; the fourth segment is extremely minute. Three stiff curved spines are situated on the inner distal margin of the basal joint. In the second maxillipede the merus (Pl. LXXIII. fig. 3) is rather less than twice as long as broad; its anterior prolongation (*i. e.* the portion extending beyond the insertion of the carpus) is about one-third the total length of the segment.

The first pair of pereopods is missing. In the second pair the carpus is nearly half as long again as the chela, and the dactylus is distinctly shorter than the palm. The carpus of the third pair is exactly the same length as the merus and more than twice the length of the chela; the dactylus is slightly shorter than the palm.

The abdomen is carinate only on the sixth somite and the median spines on the sterna are all very blunt and inconspicuous. On the lower margin of the telson there are basally two rounded lobes. The apex (Pl. LXXIII. fig. 6) is rather broad and convex. A short stout spine marks each outer angle; between these there are nine plumose setæ of which the middle one is the longest.

The petasma is very complex; its numerous lobes and folds are shown in Pl. LXXXV. fig. 1.

This species bears a close superficial resemblance to *Amalopenæus elegans**. Apart from the generic character—the presence

* My statement (Fisheries, Ireland, Sci. Invest. for 1905, V. 1906) that *G. parvus* and *A. elegans* are synonymous I now regard as erroneous. The mistake is probably traceable to the close resemblance of the two forms and to the fact that an authentic example of *A. elegans* occurs in the collection under the name of *G. parvus*.

of podobranchs on the first three pairs of pereopods—*G. parvus* is distinguished by the greater distance between the cervical and post-cervical grooves, by the strongly acute infra-antennary angle, by several details in the oral appendages, and by the form of the petasma.

GENNADAS INTERMEDIUS Spence Bate. (Plate LXXIII. figs. 7–12; Plate LXXV. fig. 3.)

Gennadas intermedius, Sp. Bate, 'Challenger' Crustacea Macrura, 1888, p. 343, pl. lviii. fig. 3.

St. 106. Off Sierra Leone. 1° 47' N., 24° 26' W. Trawl. 1850 fathoms. One male, the type specimen, ca. 48 mm.

St. 120. Off Pernambuco. 8° 37' S., 34° 28' W. Trawl. 675 fathoms. One male, ca. 46 mm.* (sub *G. parvus* Sp. Bate.)

This species is evidently one of the more primitive species of *Gennadas*, and is closely allied to *G. alicei* Bouvier. Both the specimens are unfortunately in bad condition.

The rostral crest (Pl. LXXIII. fig. 7) is only slightly elevated above the dorsal carina of the carapace, presenting a marked contrast to that found in the preceding species. The inferior margin is not convex. The fringe of setæ between the apex of the rostrum and the dorsal spine was evidently present originally, although scarcely a trace of it now remains. The antennary and infra-antennary angles are both bluntly rounded and very obtuse; the emargination between them is shallow, but not altogether missing as in *G. alicei*. The branchiostegal spine is wholly absent in the type specimen, but an exceedingly minute point is visible on one side of the second example. The hinder part of the carapace is distorted and crushed in both specimens; the distance between the cervical and post-cervical grooves (measured dorsally) is however great, probably one-half the distance from the post-cervical groove to the hinder margin of the carapace. The mid-dorsal carina is traceable throughout the length of the carapace, although faint in the posterior half.

The eyes are in bad condition, but the width across the cornea seems to be less than in *G. alicei*. The second joint of the antennular peduncle, measured dorsally, is equal in length to the third joint. The antennal scale is broken in every instance, but it is evident that it is not strongly narrowed apically.

The distal joint of the mandibular palp (Pl. LXXIII. fig. 8) is slightly longer than the width of the first joint. In the second maxilla the anterior lobe of the internal lacinia is constricted behind its apex, and is distinctly broader than the adjacent lobe of the external lacinia. In the latter lacinia the anterior lobe is fully one and a half times the width of the posterior lobe. The apex of the endopod has not exactly the same character in the two

* In the bottle with this specimen there is a label in Dr. Hansen's writing, which reads—"Agrees with the type of *G. intermedius*, Bate, not with *G. parvus*."

specimens. In the type (Pl. LXXIII. fig. 9) there are four curved dorsal spines, two long setæ at the apex of the short distal prolongation and one short spine on the inner margin. In the second example (Pl. LXXIII. fig. 10) there are three dorsal spines, a much longer distal prolongation, and six short spines on the inner margin.

The endopod of the first maxillipede falls short of the apex of the exopod. The oval third joint is twice the length of the second; the fourth joint, when present, is very minute. The basal joint bears two curved spines on its inner distal margin. The merus of the second maxillipede (Pl. LXXIII. fig. 11) is rather less than twice as long as wide, and its anterior prolongation is not more than one-quarter the total length of the joint.

In the first pair of pereopods the carpus, which is about the same length as the chela, is three-quarters the length of the merus. In the second pair the carpus is one and a half times as long as the chela, while the dactylus is evidently shorter than the palm. The carpus of the third pair is fully as long as the merus, the chela is about half the length of the carpus, and the dactylus is considerably shorter than the palm.

Each of the abdominal sterna bears a blunt and inconspicuous tubercle; the sixth somite alone is dorsally carinate. The lower margins of the telson are bluntly bilobed at the base. The apex is broken in the type; in the second specimen (Pl. LXXIII. fig. 12) it is narrow, truncate, and is armed with a pair of stout spines at each outer angle, between which are four plumose setæ.

The petasma (Pl. LXXV. fig. 3) is almost identical in the two specimens.

The resemblance of this species to *Gennadas alicei* is very marked, and it is by no means improbable that the two forms will eventually turn out to be specifically identical; in this case the name given by Spence Bate claims priority.

The chief points of difference between *Gennadas intermedius* and Bouvier's description and figures of *G. alicei* lie in the presence of a rather obscure infra-antennary angle in the former species, and in the forms assumed by the internal lacinia of the second maxilla and by the merus of the second maxillipede. The petasmata of the two species are similar.

GENNADAS CALMANI*, sp. n. (Plate LXXIV. figs. 5-11; Plate LXXXV. figs. 4 & 5.)

St. 232. S. of Japan. 35° 11' N., 139° 28' E. 345 fathoms. Two males, two females, 49-56 mm.

St. 236. S. of Japan. 34° 7' N., 138° E. Trawl. 565 fathoms. One female, 55 mm.

St. 237. Near Yokohama. 34° 37' N., 140° 32' E. Trawl. 1875 fathoms. One female, 53 mm.

* This species is associated with the name of my friend Dr. W. T. Calman, to whom I am indebted for much valuable advice and for every facility for work during my visit to the British Museum.

The rostral crest (Pl. LXXIV. fig. 5), except for the greater prominence of the dorsal and apical spines, agrees closely with that of *G. parvus*. The antennary and infra-antennary angles are both acute: the latter is rather more bluntly rounded than the former. The branchiostegal spine is prominent. The distance between the cervical and post-cervical grooves, measured dorsally, is less than one-third the distance from the post-cervical groove to the hinder margin of the carapace. Both the grooves are faint dorsally and do not interrupt the strong median carina which extends the whole length of the carapace.

The second joint of the antennular peduncle, measured dorsally, is fully three-quarters the length of the ultimate joint. The antennal scale (Pl. LXXIV. fig. 9) is rather less than three times as long as its greatest width and is remarkable for its extremely narrow apex. The convex outer margin terminates in a rather strong spine, which scarcely reaches as far forward as the lamella.

The ultimate joint of the mandibular palp (Pl. LXXIV. fig. 10) is a little shorter than the width of the basal joint. In the second maxilla (Pl. LXXIV. fig. 8) the anterior lobe of the internal lacinia is very strongly constricted behind the apex, but is not broader than the adjacent lobe of the external lacinia. The anterior lobe of the latter lacinia is very broad—about twice the width of the interior lobe. The tip of the endopod is long and narrow; it bears four terminal setæ and four curved dorsal spines behind the apex. The endopod of the first maxillipede reaches a little beyond the exopod. The third joint is practically twice the length of the second, and the fourth joint is extremely minute. The basal joint bears three curved spines on its inner distal margin. The merus of the second maxillipede (Pl. LXXIV. fig. 7) is less than twice as long as wide; the anterior prominence measures about two-sevenths the total length of the joint.

In the first pair of pereopods the carpus and chela are of equal length; each is about two-thirds the length of the merus. In the second pair the palm is almost one and a half times as long as the dactylus, the whole chela being rather more than three-quarters the length of the carpus. The carpus of the third pair is four-fifths the length of the merus; the chela is exactly half the length of the carpus and the palm is not appreciably longer than the dactylus.

The sixth somite alone is dorsally carinate. All the abdominal sterna bear a blunt and inconspicuous median tubercle with the exception of the first, which carries a very strong sharply pointed spine in the same position. This character, which is equally definite in both sexes, will probably prove of considerable specific value: it does not seem to occur in any of the species described by Bouvier.

The apex of the telson is rounded and furnished with a series of long plumose setæ (eleven in one fairly perfect example). One specimen (Pl. LXXIV. fig. 11) bears a pair of stout spines as

each of the outer angles; in another only a single spine is found in this position.

The petasma (Pl. LXXV. fig. 4) is a comparatively simple structure and is remarkably small for such a large species. The thelycum (Pl. LXXV. fig. 5) bears some resemblance to that of *G. alicei*. The triangular plate between the bases of the third pair of pereopods is not traceable in one of the females examined.

This species occupies a somewhat primitive position in the genus *Gennadas*. It is readily distinguished from all forms hitherto described, by the use of the characters suggested by Bouvier, by the prominent spine on the first abdominal sternum, and by the extremely narrow apex of the antennal scale.

GENNADAS BOUVIERI*, sp. n. (Plate LXXIV. figs. 1-4; Plate LXXV. figs. 6 & 7.)

St. 206. W. of Manila. 17° 54' N., 117° 14' E. Trawl. 2100 fathoms. One female, 28 mm.

St. 220. N. of New Guinea. 0° 42' S., 147° E. Trawl. 1100 fathoms. Two females, 26 and 28 mm.

The rostral crest (Pl. LXXIV. fig. 1) is of much the same form as in *G. parvus*; the apical and dorsal teeth are, however, rather less prominent and the inferior margin is not so decidedly convex. The carapace is dorsally carinate throughout its length. Both the antennary and infra-antennary angles are acute and strongly pronounced, and the branchiostegal spine is distinct though very small. The cervical and post-cervical grooves are very closely approximate dorsally, the distance between them is scarcely more than one-fifth the distance from the post-cervical groove to the hinder margin of the carapace.

The second joint of the antennular peduncle, measured dorsally, is about the same length as the ultimate joint. The antennal scale (Pl. LXXIV. fig. 2), which is rather narrower distally than in *G. parvus*, is a trifle less than three and a half times as long as wide. The outer margin terminates in a short spine which extends slightly beyond the apex of the lamella.

The ultimate joint of the mandibular palp (Pl. LXXIV. fig. 3) is rather shorter than the greatest width of the basal joint. In the second maxilla the anterior lobe of the internal lacinia is slightly constricted behind its apex and is rather narrower than the adjacent and similarly constricted lobe of the external lacinia. The anterior lobe of the latter lacinia is one and a half times the width of the posterior lobe. The endopod is produced to a narrow apex furnished with two terminal setæ and four curved spines on the dorsal aspect. The endopod of the first maxillipede is about the same length as the exopod. The third joint is almost twice the length of the second; the fourth joint, though small, is rather more evident than in the preceding species. The basal joint bears three curved spines on its inner distal margin. The

* Professor E. L. Bouvier.

merus of the second maxillipede (Pl. LXXIV. fig. 4) is not quite twice as long as wide; the anterior prominence is almost one-third the total length of the joint.

In the first pair of pereopods the carpus, which is slightly shorter than the chela, is three-fifths the length of the merus. In the second pair the dactylus is equal in length to the palm, the whole chela being a little shorter than the carpus. The merus of the third pair is very distinctly shorter than the carpus, the chela is rather more than half the length of the carpus, and the dactylus is almost as long as the palm.

The sternum of the first abdominal somite bears a large and stout median spine; on the succeeding somites this is reduced to a blunt tubercle. The sixth somite alone is dorsally carinate. The telson is squarely truncate apically and is furnished with five plumose setæ between the usual pair of stout lateral spines.

The three females differ slightly in regard to the thelycum. One example (Pl. LXXV. fig. 6) shows the dark yellow and toughly chitinized spermatophores partially inserted beneath the large rounded plate, lying between the third and fourth pairs of legs. A second specimen is as nearly as possible identical with this, but the spermatophores are wholly covered by the thelycal plate. In the third example, which shows no spermatophores, the posterior plate is much shorter than the other two (Pl. LXXV. fig. 7), but it is possible that this is due, at least in part, to the contracted condition of the specimen.

Attempts to remove the spermatophores proved unsuccessful, for their inner ends are very firmly fixed (probably cemented) in a pocket or spermatheca lying beneath the plate.

Gennadas bouvieri differs from all the other species in the 'Challenger' collection in the proportional lengths of the merus and carpus of the third pair of pereopods. It takes rank in the second section of Bouvier's synoptic table, along with *Gennadas talismani*, *G. tinayrei*, and *G. valens*. We have no precise information concerning the branchial formulæ of these three species, but from Smith's account* it seems probable that *valens* is a true *Amalopenæus*.

GENNADAS SCUTATUS Bouvier. (Plate LXXV. fig. 2.)

Gennadas scutatus, Bouvier, Bull. Mus. Océanog. Monaco, no. 80, 1906, figs. 8 & 13, and Rés. Camp. Sci. Monaco, xxxiii. 1908, p. 42, pl. viii.

St. 267. N. Pacific. 9° 28' N., 150° 49' W. 2700 fathoms.

One male, 21 mm.

The ultimate joint of the mandibular palp is only a trifle shorter than the width of the basal joint. The third joint of the endopod of the second maxillipede is wider than in Bouvier's figure, and the fourth joint is much less prominent. With the

* Rep. U. S. Fish Comm. for 1882 (1883), p. 402.

exception of these details the specimen agrees in every respect with the French author's account. The petasma (Pl. LXXV. fig. 2) is almost identical with the text-figure published in 1906.

The presence of podobranchs on the first three pairs of pereopods indicates that this form, like the four species already described, is a true *Gennadas*.

AMALOPENÆUS ELEGANS Smith.

St. 45. Off the mouth of the Delaware R. 38° 34' N., 72° 10' W.
Trawl. 2500 fathoms. One male, 24 mm.

The solitary specimen, which is without trace of podobranchs on the first three pereopods, is in all respects typical of this well known Atlantic species.

Three of the specimens present in the collection have not been determined:—

St. 101. Off Sierra Leone (sub *G. parvus* Sp. Bate).

This specimen, which is partially devoured by a parasitic worm, is figured in the 'Challenger' Report. Its condition is so bad that any attempt at identification is out of the question.

St. 220. N. of New Guinea (sub *G. parvus* Sp. Bate).

A single female from the above station is easily recognized as distinct from the two *G. bouvieri* occurring in the same haul. It appears to represent an undescribed species, but it does not seem advisable to attempt a description without more abundant material.

St. ? Off Bermuda (sub *G. intermedius* Sp. Bate).

The petasma of this small specimen, which was caught at the surface, does not appear to have assumed its adult form.

The following list of references may be of value to future workers at this group. So far as I am aware, it comprises all species referred to *Gennadas* (*sensu lato*) which have not been noticed in the present paper or in Bouvier's memoir:—

Gennadas carinatus Smith. N.E. Atlantic and Arabian Sea.

Smith (sub *Benthesicymus*? *carinatus*), Rep. U.S. Fish Comm. for 1882 (1884), p. 396, pl. x. figs. 6 & 7.

Alcock & Anderson, Journ. As. Soc. Bengal, lxiii. 1894, p. 147.

Alcock, Desc. Cat. Indian Deep Sea Macrura, 1901, p. 46.

McGilchrist (*G. carinatus*?), Ann. Mag. Nat. Hist., March 1905, p. 236.

Gennadas borealis Rathbun. Aleutian Is.

Rathbun, Proc. U.S. Nat. Mus. xxiv. 1902, p. 887.

Rathbun, Harriman Alaska Exped. x. 1904, p. 147, figs. 88 & 89.

Gennadas propinquus Rathbun. Hawaiian Is.

Rathbun, Bull. U.S. Fish Comm. for 1903 (1906), p. 907, fig. 61.